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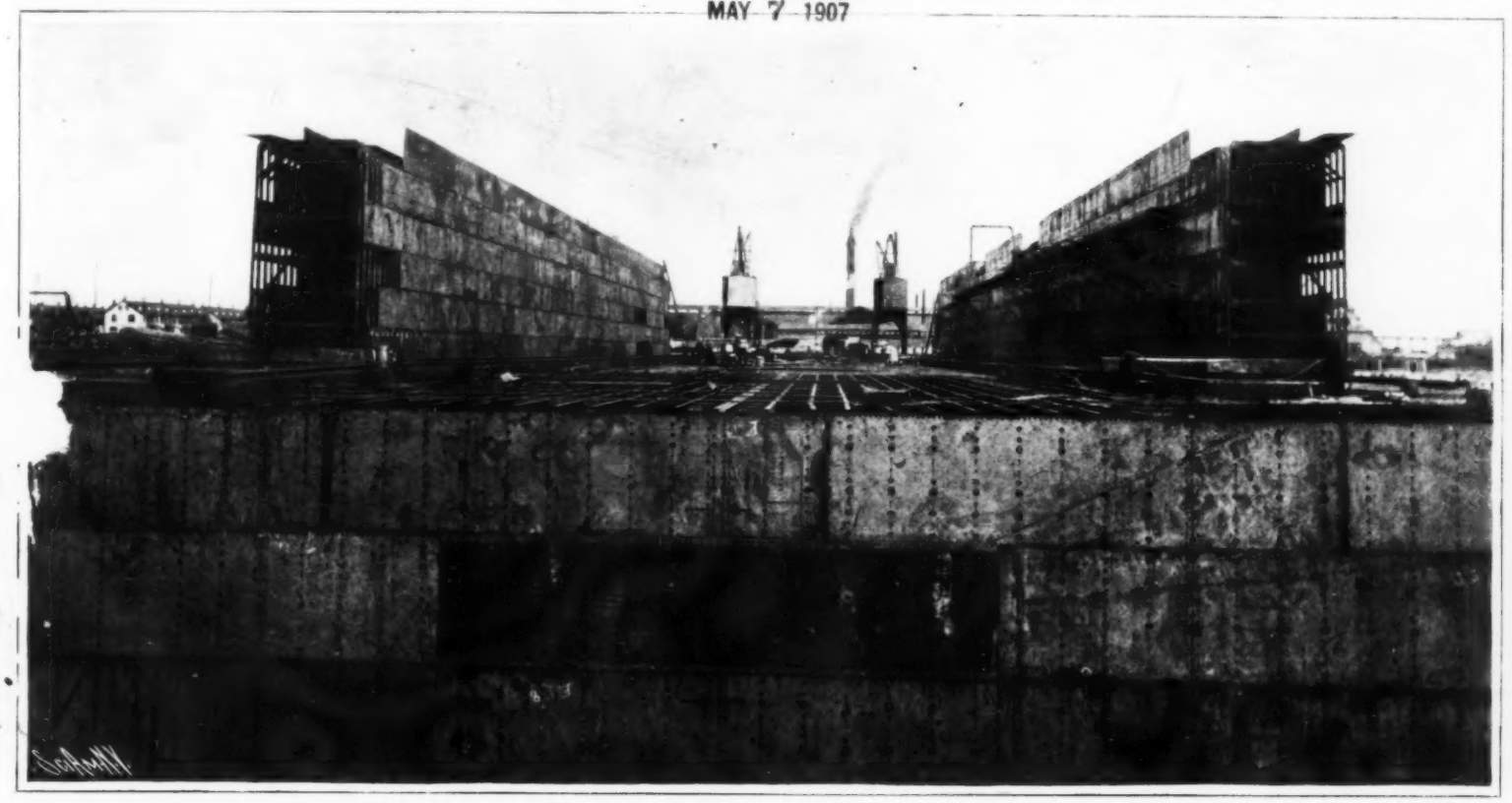
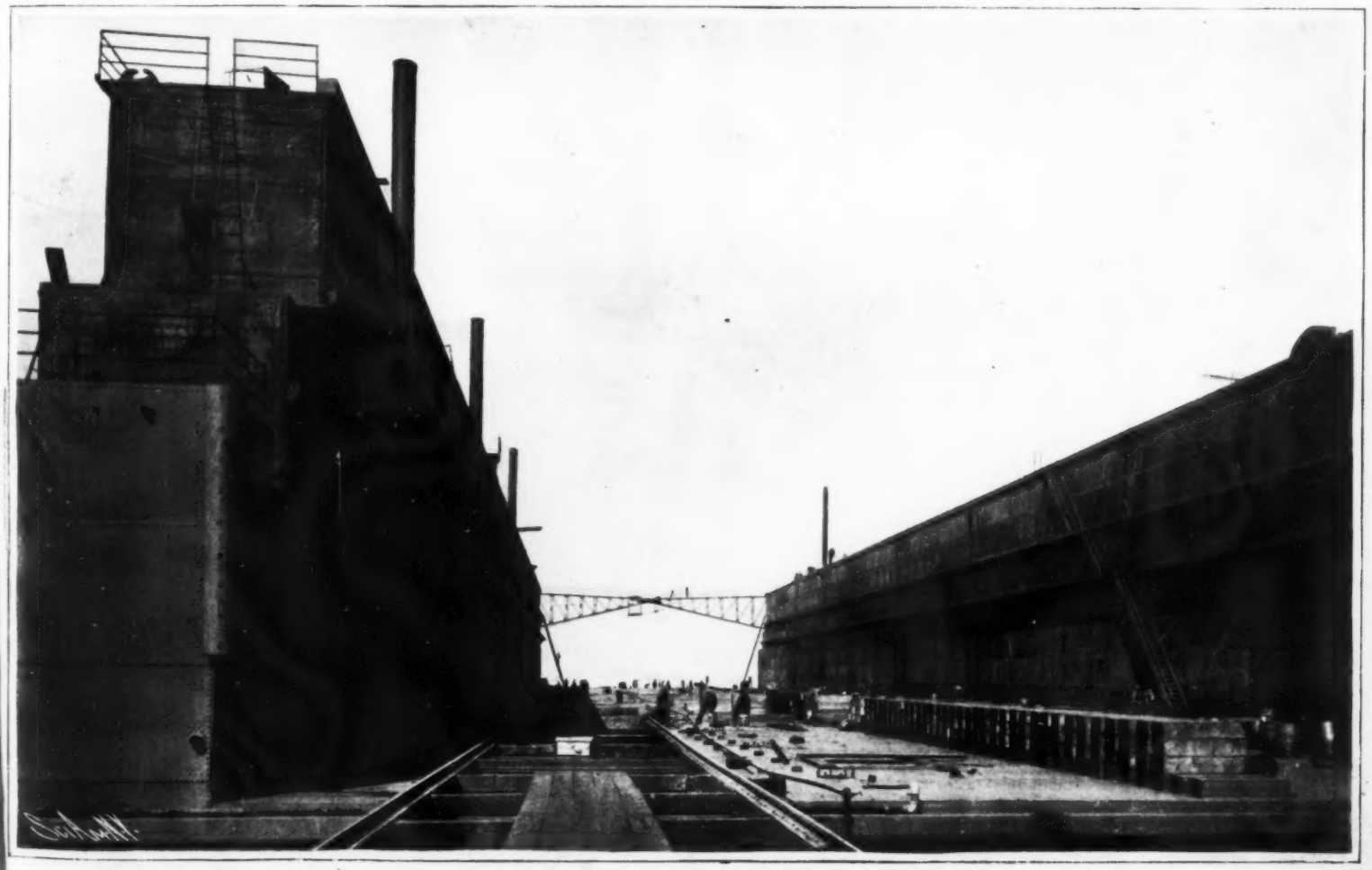


STERN END OF THE REAR PONTOON, SHOWING HEIGHT FROM DOCK FLOOR TO BOTTOM.



GENERAL VIEW OF INTERIOR LOOKING TOWARD THE BOW END.

THE CAVITE FLOATING DOCK

THE CAVITE FLOATING DOCK.*

By DAY ALLEN WILLEY.

THE drydock which has recently been completed for the United States government in the Philippines, and which will be stationed at Cavite, is especially notable for several reasons. It has the greatest lifting capacity of any mechanism ever designed, being able to lift a greater weight than any floating drydock which is now in existence. More than this, however, it includes a repair shop, and, generally speaking, might be termed a floating shipyard, since by means of it a warship or merchant vessel can be lifted completely out of the water, and simple repairs made with the equipment which it contains. The significance of this fact will be appreciated when it is remembered that the dock need only be anchored at a convenient location, and repairs made to a damaged cruiser or battleship without the necessity for the latter entering a harbor, provided of course the sea is not too rough to allow the work to be performed. The dock possesses not only these features, but is so constructed that it can be raised above the surface of the water for cleaning and repairing if necessary, as it is what is technically termed a self-docking dock, the three divisions of which it is composed being entirely independent of each other, so that each can be utilized for docking purposes if desired. For example, one of the end pontoons may be utilized for cleaning small craft, such as tugs, torpedo boats, and vessels utilized in the coast waters about the Philippines.

The structure, which was briefly referred to in a recent issue of the SCIENTIFIC AMERICAN, consists of the main or center pontoon attached to smaller pontoons at each end, the center being 316 feet in length over all, and the end sections each 170 feet over all. The great width, 134 feet, allows for side walls, which are no less than 14 feet across, thus giving an inside width of 100 feet in the clear and 106 feet between the interior sides of the walls. The stairways reaching from what is known as the tower deck to the docking floor occupy 3 feet each, but allowing for them, there is ample space to accommodate the largest warship yet constructed, with room for working on the sides of the vessel. The design of the pontoons is such that the ends of the main pontoon overhang the others. Each of the end pontoons has an outside, independent side wall high enough to allow it to be sunk and brought under the center. In this way the main portion of the structure can be lifted out of water when repairs are necessary, yet the connection is such that the entire dock is available when ships of the largest size which can enter it are to be docked. The self-docking operation can be performed either at sea or in the harbor, the only requisite being a sufficient depth of water. When it is submerged to the greatest extent, 53½ feet are required. Possibly these figures give an idea of its really enormous dimensions, but from the bottom to the top of the tower deck the side walls actually measure 63½ feet in height, the average depth of the pontoons normally being 18½ feet.

Considering its great capacity, the weight of the hull is considered by experts to be remarkably light, yet marine engineers are of the opinion that its framework and plating are stronger than necessary for the purpose required. The bottom plates used for the deck and ends are 19-32 of an inch in thickness, composed of in-and-out strakes placed transversely. In fact, nearly all of the plating is of this thickness, the deck and bottom being stiffened by longitudinal frames run between transverse bulkheads. The frames are 2 feet apart. The top frames are composed of 15-inch channels, while at the bottom 6-inch angles with a thickness of 7-16 of an inch are utilized. The average distance between the transverse bulkheads in each pontoon varies from 6 to 8 feet, the center pontoon being divided into 32 and the end pontoons into 18 watertight compartments by means of these bulkheads.

All of the pumping and other machinery is of course inclosed in the side walls, the width of each giving ample space for the installation of the largest pieces of apparatus. It is calculated that the maximum time required for pumping out all of the pontoons is four hours, as the pumps installed are adequate for the service in this length of time. The main pumps are three in number, of the horizontal centrifugal type. Each is direct-connected to a compound engine of 225-horsepower, each pump being 24-inch capacity. The discharges are controlled by wedge screw valves, and for the main pontoon three flushing inlets of 24 inches,

VIEW OF DECK (TOP OF PORT WALL) SHOWING CONTROLLER STATION AND FUNNELS.

two of 18 inches, and two of 12 inches, are provided. This service applies to the main pontoon, each end being served by an independent system consisting of one 12-inch centrifugal pump. Steam is supplied the main engines by a battery of three Babcock & Wilcox water-tube boilers, calculated to develop 900 horsepower in all. The engines were designed especially for the dock. Each rests upon a bed which is divided into two sections, so that the installation is not parallel with the framework of the dock, but at an angle to it. This plan was followed to avoid the effects of vibration on the framework as much as possible. All of the pumping machinery is installed in the port wall, the valves for flushing and drainage being controlled from one central station located on the top of the tower deck. The valve house, as it is termed, somewhat resembles the interior of a signal station on one of the modern railroad lines, as the valves are controlled by a series of levers, which are similar in appearance to those used for working semaphores, also for throwing switches. The levers are connected, however, to rods which extend downward through the walls and are attached to the valve gates by movable joints. Connecting with each valve is also an indicator, which is termed a semaphore, and placed upon the roof of the controlling station. By means of these semaphores, the dockmaster from his station on the bridge at the end can tell at a glance the valves that are open and the ones that are shut. Another interesting contrivance is a gage, by which the depth of water in any compartment is continually registered. The gage contains a column of mercury, which is controlled by pneumatic valves, in turn controlled by the pressure of water in the compartments. In all twenty-four levers are required, but so compact is the mechanism, that one or two men can perform all of the valve service proper. It might be added that the controlling station is connected with the bridge, the officers' quarters, the engine rooms, and other parts of the dock, both by speaking tubes and a telephone system, so that the valve operators are continually in communication with all portions of the structure.

The most novel features of the dock from a mechanical standpoint are contained in the starboard wall. They embrace a repair plant, an illumination plant, quarters for officers and crew which include galley, messroom, staterooms, while provision has also been made for a library and apparatus for ice making. Here also is the plant for distilling sea water for the boilers, which has a capacity of 2,500 gallons daily. In the machine shop are a swing lathe, shaper, pipe machine, as well as vises of suitable size, forges and anvils, while attached to the interior wall on this side is a swinging boom crane of a lifting capacity of one ton. The crane will be utilized for transferring plates and other weights in making repairs, while the apparatus referred to is of sufficient capacity to finish small sections of framework and sheathing to replace portions of the hull which may have been damaged. The idea of installing the machine shop originated from the fact that the dock is to be located at a point where it is difficult to make repairs to a large vessel when out of water, and it is believed the plant will avoid considerable expense as well as save time.

The mechanism referred to is operated by a 15-horsepower steam engine, which also drives an electric generator set furnishing current for eighty incandescent lamps, as well as the telephone service. Adjacent to the distilling plant are located the galley and messroom, each containing a complete equipment, while the staterooms for the officers are as commodious and convenient as the cabins in some of the Atlantic liners. The quarters include bathrooms for officers and crew, while on the port side provision has been made for shower baths for the engineers and firemen. Included in the auxiliary machinery is a very complete ventilating system, consisting of Sturtevant fans, which exhaust the air from the interior of each side and maintain a constant circulation when in operation. This is a very important factor, on account of the climate where the dock will be located. The pneumatic service is furnished by a Rand compressor having a capacity of 527 cubic feet per minute, for driving cutting and boring tools, driven by steam power. This will be utilized not only for the purposes already described, but probably in connection with the refrigeration apparatus, if installed.

As already stated, the Cavite structure has the greatest lifting capacity of any floating dock in the world. It has been designed to elevate 16,000 tons weight to a height which will allow a freeboard of at least two feet with one foot of contained water, while it is expected to support a weight of 20,000 tons when the lower deck of the dock is awash. Yet such is the strength of the structure, that it is estimated the entire deflection will not exceed two inches transversely, and three inches in a longitudinal direction under the greatest strain. When ready for service with all of its machinery aboard, the dock will weigh 10,600 tons, the structural material it contains representing 9,200 tons, the machinery 576 tons, water for boilers and plant 280, and the anchors and chains 50 tons. Its displacement to the level of the pontoon deck is calculated to be 35,129 tons, and its displacement per foot 1,900 tons. As has already been stated in the SCIENTIFIC AMERICAN the structure is to be tested in Chesapeake Bay by lifting the heaviest battleship of the United States navy now in commission. If the test is successful—and there appears to be no doubt that it will be—the dock will indeed be a credit to American skill and ability, for it is entirely of American design, its construction was supervised by American engineers, the work performed by American artisans, while all of the material came from plants in the United States. It is an interesting fact that the design from which the dock was built originated with the Maryland Steel Company, which constructed it, the designer being Mr. Sven Anderson, manager of the dock building department, assisted by Mr. Gerhard Styrlander, chief draftsman. The construction was under the supervision of Mr. Leonard M. Cox, civil engineer of the navy, to whom credit is due for suggesting the design of the engines as well as the installation of the repair plant and other valuable features. The dock was built at the marine department of the Maryland Steel Company, of which Mr. Andrew G. Wilson is manager.

To tow this great hulk to its destination is also a feat of no little importance. It has been decided to take it by the way of Cape of Good Hope, owing to the possibility of grounding or some other accident in going through the Suez canal. To transport it the thousands of miles required, a steamship of 2,000 or 3,000 tons will probably be utilized for the principal towing service, as well as to carry sufficient coal for itself and the auxiliary towboats needed, not only for motive power, but for guiding it in a seaway.

BEGINNING CONSTRUCTION OF MAIN PONTOON WALLS, SHOWING METHOD OF FRAMING.

THE CAVITE FLOATING DOCK.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

GAS PRODUCER POWER PLANTS.*

By SAMUEL S. WYER.

THE fact that gas producer power plants have received so little attention in America may be attributed to five conditions: (1) Ignorance and prejudice; (2) newness of work; (3) inadaptability of gas engines; (4) fuel economy not imperative; (5) smoke nuisance not given attention.

1. The only literature pertaining to gas producer power plants is that found in the various technical journals and in the transactions of engineering and

* Read at the meeting of the American Institute of Mining Engineers.

other technical societies. In many cases the papers are of a fragmentary character, and seldom are they complete or comprehensive. It may be that the lack of reliable data available to engineers is the cause of the ignorance and prejudice that exist concerning this important branch of engineering.

2. The manufacture of producer gas is an old process, and gas engines have been developed to a very high stage of mechanical efficiency, hence there is no valid reason why such installations should be regarded as experimental.

The Winchester Repeating Arms Company, at its plant in New Haven, Conn., has a Loomis-Pettibone gas producer plant, built primarily to furnish gas for fuel purposes (such as for annealing ovens, furnaces, etc.); a 100-horse-power Westinghouse gas engine was installed some time ago, and later three direct-connected units, each of 175 horse-power, have been ordered. At the present time this example is one of the best instances in America of an industrial producer gas plant where gas is furnished both for fuel and for power.

The following list comprises some of the larger gas producer power plants now in operation in America:

Montezuma Copper Company, Nacozari Sonora, Mexico.

Guggenheim Exploration Company, 700 horse-power, Santa Barbara, Chihuahua, Mexico.

Detroit Copper Mining Company, 1,000 horse-power, Morenci, Arizona.

Rockland Electric Company, 1,000 horse-power, Hillburn, N. Y.

Potosina Electric Company, 600 horse-power, San Luis Potosi, Mexico.

Velardena Mining and Smelting Company, 2,000 horse-power, Velardena, Durango, Mexico.

Sayles Bleacheries, 250 horse-power, Saylersville, R. I.

It is obvious that much has already been accomplished in this important field of power generation.

3. No gas producer power plant can be successful unless the gas engine is adapted to suit the particular gas available for its use. On the authority of Westinghouse, Church, Kerr & Co., an engine which will develop 100 horse-power with natural gas will give only about 80 horse-power with producer gas—a loss of 20 per cent. With a 200-horse-power engine this loss would be about 15 per cent, and with sizes above 300 horse-power it would be about 10 per cent. Hence, the obvious necessity of designing the engine to suit the particular fuel it is to use. Several failures have been made by neglecting this important point.

4. In the list of plants given above, it will be noticed that most of them are in remote regions where the cost of fuel is high, hence the high economy of the gas producer plant was necessarily a feature that commended itself.

5. The laxity of the laws regarding the smoke nuisance has not made it imperative for manufacturers to give attention to the prevention of smoke. As soon as regulations concerning the smoke nuisance are enforced the gas producer industry will receive a new impetus on account of the easy solution that the gas producer plant offers for this trouble.

Data relative to the design, operation and maintenance of gas producer plants, mostly highly favorable to the use of such plants, are given as follows:

1. A good gas producer, from the very nature of its construction and operation, does not allow the smoke to escape into the atmosphere; hence the gas producer itself presents a practical solution for the elimination of the smoke nuisance. The non-requirement of a chimney means a large saving in the first cost and in the maintenance of a power plant, and is an additional advantage in plants where the æsthetic features of the design are of importance; for instance, in the case of a municipal power plant.

2. The cost of labor required to operate a gas producer plant is about the same as that required in a steam plant of similar size. However, during the time that a gas producer plant is idle it requires less attention than does a steam boiler. In the case of a municipal pumping station, the labor required to operate the producer gas plant would be one-half that of a similar steam plant, the gas plant being operated as follows: The gas producers to use coal for supplying the gas to operate a three-cylinder vertical gas engine direct connected to a triplex double-acting power pump. In this case the usual fire engine will be dispensed with, and, should a fire occur, the requisite pressure obtained by pumping directly into the system. For ordinary domestic supply the pump will deliver the water into a water tower, from which the mains receive the supply as needed. In every case the maximum quantity of water required during a fire is much larger than the average domestic consumption; hence the pump must be designed for this maximum quantity. As a result the working of the pump at its full capacity for six out of twenty-four hours would furnish enough water for the daily domestic consumption; the pump would usually be operated from 7 to 10 A. M. and from 3 to 6 P. M.

A gas holder of sufficient capacity to run the pump for thirty minutes is to be filled before the producers are closed down. Compressed air is to be used to start the engine, which may be put into motion simply by moving a lever. The engineer is to live adjacent to the plant so that when an alarm is sent in to the hose company and simultaneously to the engineer's home and to the plant it would be possible for the engineer to have the pump at work direct into the system by the time the fire company would reach the fire and make hose connections.

Since the gas holder would supply the engine until the producers could be started, the above scheme of operation eliminates the necessity of a night fireman and the keeping up of at least 70 pounds of steam pressure in a steam plant. A similar arrangement could be equally well adapted for fire purposes in connection with large industrial plants. With regard to the skill required, a producer gas power plant does not require any greater skilled labor than does a steam plant of similar size; however, in some cases it may require time for men trained to handle steam apparatus to become accustomed to gas engines and gas producers.

3. Two well-known engineering concerns give the following data regarding cost of installation:

The cost of gas power plants, including gas generating plant and gas engines, up to 500 horse-power, is about 25 per cent higher than the cost of a steam plant of similar size. Large plants, from 1,000 horse-power upward, cost about the same as a first-class steam plant of similar size.

ONE OF THE MAIN EJECTING VALVES AND OUTLET CONDUIT.

4. The cost of repairs on a gas producer plant will not exceed that of a boiler plant.

5. In order that a gas producer plant shall be commercially successful, it must be able to make, from a low-priced fuel, gas that is sufficiently clean for use in an engine. Bituminous slack is usually the lowest priced fuel to be had; however, anthracite culm, or even wood, may be cheaper in some localities. In all cases the percentage of sulphur must be low if the gas is to be used in a gas engine. Frequently the use of a mechanically washed coal will be economical.

6. The only reliable way to remove tar and other hydrocarbons from gas made from soft coal is to have the producer so arranged that the gas comes in close contact with an incandescent mass of carbon. No mechanical means has yet been found to be successful, although several forms of centrifugal apparatus have been tried. For the removal of fine dust particles, however, centrifugal fans have proved very satisfactory.

7. The stand-by loss of heat is very small, being limited to radiation only; a gas producer is tightly closed during the time it is not making gas and the entrance of air is thereby prevented. This feature is a marked advantage over a steam boiler under similar conditions.

8. Even after a producer has been idle for several hours it may be started and can be working at its full capacity within fifteen minutes. A gas holder is generally used in connection with the producer, from which a supply of gas can be taken to start the gas engine instantly and keep it in operation until the gas producers are making gas.

9. A gas producer may be stopped instantly by simply shutting off the supply of air and steam.

10. The gas from the gas producer is quite uniform in composition, and as it usually passes first to a holder before reaching the gas engine, it becomes thoroughly diffused, thus insuring a still greater uniformity.

11. The thermal efficiency of gas producers is generally about 80 per cent and in some cases it is even higher than this value.

12. It is much easier to use an automatic feeding device on a gas producer than on a steam boiler, because all producers are placed vertically and the fuel can be dropped into position by gravity. The use of an automatic feed always decreases labor and insures more uniformity in the composition of the gas produced.

13. The rate of gasification in a gas producer is relative to the character of the coal used. The best rate determined by experience is 12 pounds of coal per square foot of grate area per hour, although some makers have advised as high as 20 pounds of coal. Experience has also demonstrated that too rapid driving opens a wide door for the admission of adverse gasifying conditions.

14. The amount and frequency of poking a gas producer will depend on the nature of the fuel and the design of the producer. The mechanical agitation of the fuel bed (as in the Kitson and Fraser and Talbot producers) eliminates poking entirely. In using bituminous coals the difficulties of clinker formations are augmented by the production of coke. The judicious use of a steam blast and automatic feeding will generally reduce poking to a minimum and, in some cases, will eliminate it entirely. Hand poking is very laborious for the attendant and usually it will be shirked whenever possible. Gas will usually escape around the poke holes while the producer is being poked, which will vitiate the air in the producer room and also affect the regularity of the composition of the gas.

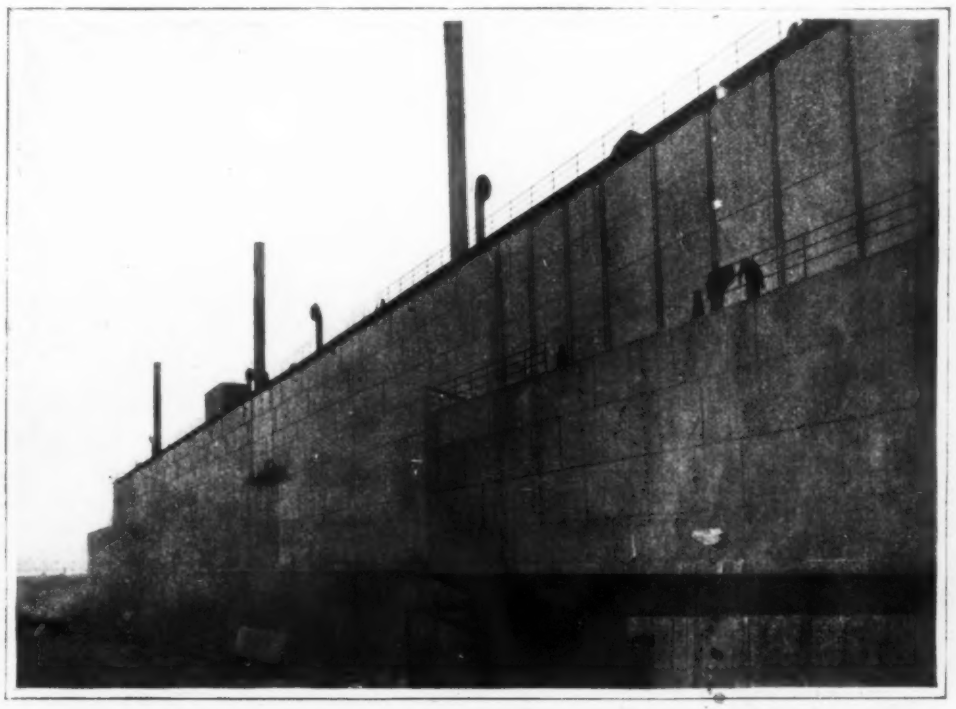
15. The caloric value of producer gas varies from 125 to 150 B. T. U. per cubic foot.

16. The generation of 1 brake horse-power per hour with from 1 to 1.25 pounds of coal or 3 pounds of wood is very common in producer gas power plant practice at the present time, and the gas contains at least 80 per cent of the heat energy resident in the fuel.

17. A very important advantage of the producer gas installation is that the gas does not condense or lose power on its way to the gas engine. On the contrary, the cooler the gas the better it is for the engine. With steam the condensation is considerable.

18. It is easy to prevent leakage of gas from the piping, owing to the low pressure of the gas (about 2 inches of water); whereas, with steam, there is often much loss and inconvenience on this account.

19. By using isolated engines a large saving in shafting may be made in many cases. It is not possible to do this in steam plants and still maintain a good economy.



EXTERIOR OF DOCK, SHOWING ITS GREAT HEIGHT (63½ FEET). AT THE TOP APPEARS THE CONTROLLER STATION.

THE CAVITE FLOATING DOCK.

20. The floor space required for gas holders, gas producers, and auxiliary apparatus is about the same as that required in a steam plant; the holder, however, need not be placed adjacent to the producers, but at any other convenient place.

21. A gas producer plant is under much better control than the average steam plant, because in the gas

producers the air supply rate of gasification as well as the fuel supply can be regulated more easily.

22. One of the most potent advantages of the gas producer plant compared with the steam plant is the ability of the former to store the heat energy in a holder where it may be drawn upon for immediate use. In this way irregularities and fluctuations of load need not affect the regularity of the action of the gas producer. This condition means an economy of operation and convenience of use that are impossible with any steam plant.

23. Another important advantage of the gas producer power plant is that, in many cases, the gas may be used both for power and for metallurgical purposes, the same pipes being used to supply engines and furnaces. The plant of the Winchester Repeating Arms Company, at New Haven, Conn., illustrates an installation of this character.

24. In many cases it is a serious matter to secure a sufficient supply of water for a steam plant and sometimes, even with an adequate supply, the quality of the water is such that it is entirely unfit for use in a steam boiler. One of the most annoying difficulties of many steam plants is the trouble caused by the corrosion and subsequent cleansing of the boilers, together with the maintenance of feed water purifiers.

The gas producer power plant forms an almost ideal solution for the problem of water supply. With a producer in normal condition, the consumption of water will not exceed 2 pounds per brake horse-power hour. The water used in cooling the gases in the scrubber may be cooled in a simple tower and used repeatedly.

25. There is no difficulty in piping gas for several thousand feet in order to reach an engine that drives an isolated machine; this often makes it possible to dispense with abnormal lengths of line shafting and the consequent friction loss or other unsatisfactory methods of power transmission. This condition is especially valuable in places where electrical power is not used.

26. Standard gas producers now range from a few horse-power to more than 500 horse-power in size.

27. There is less danger of explosion in a gas producer plant than there is in connection with a steam plant; moreover, should an explosion occur it would be much less violent and destructive than that of a steam boiler.

28. If desired, the gas producer plant may be placed near the fuel supply, which in many cases would reduce the expense of transportation, the gas being piped to the gas engines of furnaces where it is to be used. This arrangement, which is impossible with a steam plant, means a decided saving in favor of the gas producer installation.

29. The preceding paragraphs show the many strong advantages of the gas producer as a power generator; the large number now in successful operation shows that the experimental stage has been passed and that they have become a formidable competitor of the steam boiler. The time is not far distant when gas producer locomotives for railroad service, gas producer portable engines and gas producer power plants for marine service will be in common use.

The advantages of the gas producer for each of the above three classes are:

I. Gas Producer Locomotives, being—

1. Smokeless.—*a*. Trains and stations may be kept cleaner; *b*, tunnels may be passed through with greater safety; *c*, comfort of passengers will be increased.

2. Cinderless.—*a*, Fuel loss will be decreased; *b*, comfort of passengers will be increased; *c*, large fire losses due to sparks will be eliminated entirely; *d*, insurance rates on property adjacent to railroads will be less.

3. More Economical.—*a*, In fuel, since the amount used would be less than one-half that used on steam locomotives; *b*, in water, since the amount used would be less than one-eighth that used on steam locomotives; *c*, in time, since the time required to take fuel and water would be less; *d*, in labor in firing on account of automatic feed and decreased amount of fuel used; *e*, in idleness, since stand-by losses would be very low; *f*, in number of fuel and water stations required.

4. Safer, since the danger of boiler explosions is eliminated.

II. Gas Producer Portable Engines, being—

1. Smokeless.—*a*, Large fire losses due to sparks will be eliminated entirely; *b*, insurance rates on property adjacent to where an engine is used would be less.

2. More economical in, *a*, water; *b*, fuel; *c*, labor; *d*, time required to secure fuel and water.

3. Safer, the danger of explosion being eliminated.

III. Gas Producer Power Plants for Marine Service, being—

1. Smokeless.—*a*, Ships may be kept cleaner; *b*, passengers will have more comfort; *c*, a battleship could conceal its location more easily.

2. More economical in, *a*, fuel; *b*, water; *c*, time required to fuel; *d*, bunker capacity; *e*, floor space; *f*, apparatus required, since all of the condensing machinery would be dispensed with.

[Concluded from SUPPLEMENT No. 1538, page 24643.]

GLASS PAVING AND BUILDING BRICKS.

ITALY.

Milan.

THE use of paving bricks made of glass in Milan is limited to cover underground passages and for floor lights. In some recently erected buildings they have been adopted for ground and upper floors on account of the light obtained. They are also coming into use for partition work in some hospitals on hygienic principles.

These bricks, or so-called "tiles," are manufactured in Italy, but are also largely imported. Bricks made from glass for building purposes are not manufactured in this district, but I have been informed that the "Societa di S. Gobain," at Pisa, an Italian branch of the well-known French company, has experimented in them, with what success I am not in a position to say. This company manufactures the so-called "Dalles," which are also used for paving and roofing purposes.—Harlan W. Brush, Consul, Milan, Italy.

Turin.

There is a glass factory in this city making paving bricks from glass in limited quantities; enough, however, to supply the demand. An official of the plant informed me that they use the same material as in the manufacture of heavy ordinary glass. The bricks produced are dark green and are used in paving places where light is desired in basements of business houses and other buildings. They are extensively used in modern buildings.

In one of the leading banking institutions of the city, of modern construction, the lobby office floor, which is about 36 by 58 feet, is entirely paved with glass bricks laid in iron frames for the purpose of admitting light into the basement where are numerous private boxes. The glass bricks used in this floor are light, of superior quality, imported from La Gobain plant, France, and, I am informed, are made of material similar to that used in the production of fine plate glass. This firm has a subplant located at or near Pisa, Italy, for the superior material to be obtained in that region for the purpose.—Pietro Cuneo, Consul, Turin, Italy.

NETHERLANDS.

Paving bricks are not manufactured in the Netherlands. Of glass bricks sold, Huinck & Imhofe, of this city, who are the sole representatives in the Netherlands for the manufacturers, refuse to give their names, and the dealers in building materials and the contractors and builders using the bricks know nothing of their origin. The bricks are made of pressed glass waste in various shapes, mostly square and oblong, are gray in color, exceedingly hard, and are not transparent. Huinck & Imhofe showed me samples of more than twenty kinds, some of them made in imitation of plaster ornaments. The demand for the bricks, while still limited, is growing. The plain bricks are used to advantage for paving bridges and vestibules of large public and office buildings, and also for wall coverings in chemical factories. As the bricks are insulating they will be used in the electric power houses now in course of construction for the electric street car companies of Rotterdam and The Hague. The ornamental bricks are principally destined for bridge decoration. Up to date, however, there has been no demand for these.

Blown-glass building bricks, hollow, and of octagonal shape, are used in the Netherlands to a limited extent. The only dealer handling them sells them in small lots of from 50 to 100. They are used principally for light-giving purposes in walls of machine shops and conservatories. The bricks are of a greenish color and transparent. The total consumption of these for Rotterdam and vicinity has been 14,000 during the last three years. The bricks have been for sale at Rotterdam during the last six years, but it took a long while before any demand was created.—S. Listoe, Consul-General, Rotterdam, Netherlands.

RUSSIA.

Glass bricks adapted exclusively for paving purposes, so-called "prisms," are produced by the Russian firm "Actiengesellschaft Zombkowiczer Glasfabriken" in its factories situated at Zombkowice, Poland. The article is manufactured, pressed and uncut, from ordinary pellucid glass metal, in the form of oblongs adjustable by means of iron frames. As coverings for light shafts, etc., they are considered to answer the purpose just as well as the article manufactured by the "Luxfer Prism Syndicate," the introduction of which has also been tried here, but as yet without any success worth mentioning.

Another kind of brick of glass manufactured according to the "Système Falconnier," of which the Warsaw firm Steck is the general representative for Russia, is produced in Kielce, Poland. These bricks, made of green blown glass and hollow, are mostly utilized for the construction of windows, partitions, etc. The cases in which they have been employed in these provinces are as yet too few to allow conclusions to be drawn with regard to their practical value.—Chr. Schulin, Vice and Deputy Consul, Riga, Russia.

SPAIN.

The only manufacture of paving bricks from glass in Spain is that recently established at San Sebastian, in the province of Guipuzcoa, where a stock company with an authorized capital of 5,000,000 pesetas ($750,000) has been formed under the name of the "Sociedad Española de Piedra Vidrio y de Construcciones Garchey" (the Spanish Glass Stone and Garchey Construction Company). As its name implies, the company will work the Garchey patents. Important works are in course of erection at the little seaport town of Pasages, and sanguine hopes are entertained that a large demand will speedily grow up in this country for these bricks, owing to the many purposes for which they can be utilized and the evident advantages they offer.

The devitrification of glass whereby its transparency and brittleness are replaced by an opaque appearance and a hardness resembling granite, is no new discovery. Many eminent French scientists had succeeded in devitrifying glass, but they had failed to find a practical process whereby a marketable value could be given to the product.

Mr. Garchey has discovered a system for thus altering the molecular structure of glass which enables him to offer a new product to builders, the practical value of which can hardly be overestimated. In appearance it resembles granite with a variety of tones of color, these depending on the nature of the metallic oxides contained in the materials used in its composition, or which may be purposely added in the process of manufacture. It retains all the qualities of ordinary glass, in so far as to be unaffected by acids, being, therefore, particularly suitable for the floors and walls of hospitals, operating rooms, chemical laboratories, etc., as also for slaughter houses, or even stables.

It is further claimed that these glass bricks do not absorb moisture, being nonporous, and that therefore they form the most hygienic material known for paving the streets of large cities. Their hardness is greater than that of any kind of stone used in building, tests showing that it required a pressure of close to 29,000 pounds to the square inch to break the material, or 22 blows from a weight of 9½ pounds falling from a height of 39 inches.

The special features mentioned also give the bricks a great resistance to wear and tear, as may be seen from the report of the laboratory of the army corps of engineers, a copy of which I append. In this report a comparison is made between Garchey glass stone and Carrara marble, it being found that the former is fifteen times harder than the marble. It might be feared from the fact that these bricks are made from glass that they would be too slippery for street pavements, but it is stated that their rough, corrugated surface makes them no more slippery than any other paving stones.

Finally, the manufacturers of these glass bricks claim that they are absolutely unaffected by rapid changes in temperature; that they are nonconductors of heat, and therefore particularly adapted for building purposes; and that for electric-generating stations and other electric purposes no better insulating material can be found than Garchey glass stone, which can resist a tension of 60,000 volts.

Five glass works in France and one in England are now making Garchey glass stone, and negotiations are in progress for working the patent in Russia, Austria-Hungary, and Roumania.—Julius G. Lay, Consul-General, Barcelona, Spain.

Spanish Army Corps Tests.

(Report on Garchey patent glass stone by the laboratory of the army corps of engineers, Madrid, Spain.)

1. Structural remarks: The samples present a very marked vitreous appearance, homogeneous greenish color, and compact texture; free from extraneous bodies and bubbles.

2. Determination of specific weight: This has been ascertained by the volumetric process, utilizing the dust which passed through a sifter of 900 meshes to the square centimeter, and which failed to pass one of 4,900. Three tests were made with the average result, specific weight, 2.60.

3. Apparent density: To determine this the samples were dried in a Fremy stove at a temperature of 40 deg. C., and were afterward weighed in fine scales. The volume was found by means of hydrostatic scales after the samples had been first saturated in water and successively weighed in the air and submerged in water. The difference between these two weighings in grammes represents the volume of the sample in cubic centimeters and fractions of a centimeter. These tests were made with the average result, apparent density, 2.59.

4. Absolute porosity: This has been deduced from the specific weight and the apparent density, dividing the difference between the two by the specific weight, thus a figure is arrived at which represents the relation between the volume of voids and the total. Absolute porosity, 0.0038.

5. Tests of resistance to frost: For these tests four samples were used which had been previously saturated in water under the bell of the pneumatic machine at a pressure of 50 centimeters of mercury. They were then subjected during four hours to a temperature varying between —10 deg. and —15 deg. C. This operation was repeated twenty-five times with the following results:

Resistance to Frost.

Samples.	Weight.	Weight after saturation.	Percentage of water to weight.	Effect of freezing.
	Grms.	Grms.	Grms.	
G 5	907.1	907.7	0.0006	No apparent change.
G 6	714.0	715.5	0.0020	Do.
G 7	827.9	828.8	0.0010	Do.
G 8	810.3	811.4	0.0010	Do.

6. Resistance to wear and tear by friction: This test was made with a Dorry machine, constructed by Digeon, silicious sand being used, which passed through a hair sieve of 324 meshes to the square centimeter and not through one of 900. The stone used for comparison was Carrara marble. The stone was made to run at the uniform speed of 2,000 revolutions per hour, and both the sample under test and the other stone used were weighted with 250 grammes to every

square centimeter of surface under friction. The following are the average results of these tests:

Resistance to Wear and Tear.

Samples.	Weight per square centimeter.	Loss by wear and tear in 2,000 revolutions.	
		In height.	In weight per square centimeter.
	Grms.	Cm.	Grms.
Carrara marble	250	1.50	3 90
Garchey glass	250	0.10	0 34

The weight was applied vertically with the center of gravity in both samples.—José Marva, The Colonel Director, Madrid, Spain.

SWITZERLAND.

St. Gall.

Upon consulting the principal architects in this city, I learn that glass bricks of different shapes and sizes are manufactured by the Falconnier Glass Works, in Horw, Canton of Lucerne. The bricks are considered most durable, and give great satisfaction. Their use in building has not been extensive as yet in St. Gall, consequently the architects have not been able to test their durability on a large scale. The few experiments that have been made in this city are restricted to roofing, for the purpose of conducting light into dark rooms, for cellars, subways, engine houses, etc. Glass paving bricks are imported into Switzerland from Germany.—Thomas Willing Peters, Consul-General, St. Gall, Switzerland.

Zurich.

Glass bricks for paving and building purposes are not made in this consular district. The city of Zurich, some fifteen months ago, ordered for trial a quantity of glass bricks from France to pave several hundred yards of a street where the traffic is very heavy. In a very short time, however, the space paved became in such bad condition that the bricks, being too brittle, had to be replaced by other material. It is thought that glass bricks may do well enough for paving sidewalks, but so far no trials have been made in this city, nor elsewhere in the district.—Joseph Simon, Deputy Consul, Zurich, Switzerland.

UNITED KINGDOM.

Birmingham.

Glass bricks are not manufactured here, but I find that the Crystalline Company, located in my consular district, is preparing to make them for paving and building purposes.

This firm has patented and has for some time been using a special process of manufacturing tiles from glass combined with china clay, having upon their rear surface rough "keys" or "grips" enabling the tiles to hold very firmly into a special cement, also patented, which expands and contracts "at the same ratio as the glass tiles." A publication devoted to Black Country industries, describing this tile, which it considers ideal and which has had a large sale, states that while the ordinary tiles were made from earthenware and had excessive weight and bulk and were difficult to use for covering irregular surfaces or for the adornment of ceilings and the lighter forms of decorative work, these difficulties have been overcome in the glass and china tiles. The new tile is hard and almost indestructible, light in weight, easily affixable to either regular or irregular surfaces, retaining its brilliancy without crazing, that is, cracking on the surface, and because of the grip or key at the back adhering perfectly and permanently, and it can be manufactured in any kind of curve, angle or molding. The publication also claims that the company has a process by which it is possible to produce any number of colors in glass, as many as thirty-six colors in one piece.

Finding that a colleague at Lyon, France (Consul John C. Covert), had reported the use in Lyon of glass bricks for pavements and for building purposes, I sent a copy of his report to the Stourbridge manufacturer referred to. In acknowledging its receipt the Stourbridge manufacturer says that he is very well acquainted with the Garchey method, and while the material results are much like those of his own process, he "gets a porous glass stone something like lava," and calls attention to the fact that many years before M. Garchey produced his glass bricks, the old French chemists, Reaumer and Pelouze, pointed out that "devitrification" was possible. He adds that Garchey certainly produces valuable material for building purposes, and that there are other firms in Jeumont and other parts of France and in Brussels making building blocks very cheap, and that these firms can also make imitation faience of glass stone, now largely used for building purposes. My Stourbridge correspondent expresses the belief that glass in various forms will in time supersede ceramic productions, because cheaper and more lasting, and not liable to craze, and he is very optimistic about the chances of his own process for making glass bricks, which, though requiring larger initial outlay, will be, he believes, cheaper than any of the others. Though unable to verify it, he has heard that a firm in England, near Castleford, has taken up the manufacture of bricks by the Garchey process.—Marshal Halstead, Consul, Birmingham, England.

Leeds.

About fifteen or twenty years ago bricks were manufactured in England from the slag left over in iron and steel works. In a trial section of paving with these bricks, that their practical usefulness might be determined, two serious and unexpected features were developed. As the bricks wore they became slippery, and while the slag brick was generally as hard as glass, soft spots occurred, causing holes therein. As neither of these objectionable features could be corrected, the attempt at the manufacture of slag bricks proved a failure. This was the nearest approach ever made in this district to the manufacture of glass bricks.—Lewis Dexter, Consul, Leeds, England.

Newcastle-on-Tyne.

The nearest approach here to glass bricks are scorial bricks manufactured in the Middlesbrough district from the waste slag from the ironstone blast furnaces. These bricks are only used for street paving, etc., and are not intended for building purposes, at least no case is known where they have been so utilized. The price varies from $2.68 to $3.16 per ton, free on trucks at the works. During the last ten years scorial bricks to the value of about $69,000 have been exported from Middlesbrough to the United States, chiefly to Philadelphia.—Horace W. Metcalf, Consul, Newcastle-on-Tyne, England.

Sheffield.

There are no bricks made from glass in this consular district, nor are any bricks made from this material used in the city of Sheffield either for paving or building purposes.

The authorities of the city have been engaged for some time in trying to convert the refuse from its garbage destructors into slabs for use in the construction of sidewalks and footpaths. This is done by grinding the slag to the requisite fineness, and in combination with cement, molding it into slabs. Fairly serviceable walks are obtained, and the garbage refuse is in this way disposed of. The experiment was commenced to determine whether this method of disposition would be more economical than to purchase ground and dump the refuse from the destructors thereon, and the experiment has not yet been tried sufficiently to warrant those engaged in it to advise its use generally.—Charles N. Daniels, Consul, Sheffield, England.

SOME INTERESTING SCIENTIFIC NOVELTIES AT THE BRITISH ROYAL SOCIETY SOIREE.

By the English Correspondent of SCIENTIFIC AMERICAN.

AT the first soiree held this year by the Royal Society of Great Britain recently were exhibited a varied display of scientific novelties contributed by not only leading British scientists, but one or two interesting exhibits from foreign scientists as well. Foremost in this direction was the instrument devised by Prof. Ernest Ford Nichols, of Columbia College, N. Y., in conjunction with Prof. G. F. Hull, for measuring the pressure of light. This apparatus comprises a small torsion balance swinging in a vacuum upon which a beam of light is projected. The remarkable feature of this device is the accuracy of the measurements obtained, the results not varying beyond one per cent of the theoretical results according to the formulæ of Maxwell. An interesting lecture upon this novel instrument, accompanied by curious experiments, was delivered by the inventor. In the course of his paper narrating the results and work of his investigations Prof. Nichols showed in action the instrument for illustrating the repulsion of comets' tails by light. This appliance is a form of vacuum hour glass and contains some sand mixed with very light puff ball spores extending through the neck. The falling of a beam of light upon the mingled sand and seed spores causes the two to separate and blows out the spores.

The direct-reading cymmometer devised by Prof. J. A. Fleming for measuring the length of waves used in wireless telegraphy was also exhibited. There is an oscillation valve which comprises practically an incandescent lamp with the filament surrounded by a ring of platinum alloy which rectifies electrical oscillations and enables them to be measured in an ordinary galvanometer. These valves, each of which stops twelve volts, can be arranged in parallel, and when combined with a dead beat galvanometer can be used as a wireless telegraphic receiver. The apparatus supplants the coherer and other devices of a similar character. The signals are given thereon by short and long deflections of the galvanometer. The device is based upon the phenomenon that electricity will pass with the negative electrons from a hot carbon filament to a metal electrode, but will not pass in the other direction.

Another device for use in connection with wireless telegraphy was that for converting continuous current into alternating current. In this device the current is led to a pair of plain slip rings, through the primary of an induction coil, with the usual rheostat and ammeter in circuit. The slip rings are connected to a two-part commutator, which is caused to rotate by means of a small motor. The brushes of the commutator constitute the terminals of the second circuit which is in series with a large capacity electrolytic condenser. By this means the unidirectional pulses of current pass through the primary of the coil. The odd pulses are currents from the dynamo which also charge the condenser. The even impulses are the discharge currents of the condenser and are rectified in direction by the commutator. Owing to the fact that the commutator is only reversed at the instant when no current is flowing either in or out of the condenser there is no sparking. The alternating current in the condenser circuit can be passed in series through the primary of a transformer for producing high-tension alternating currents. The electrolytic condenser comprises a pressed-steel vessel measuring 10 inches square by 12 inches in height, charged with a salt solution which forms one of the coatings. A pair of crumpled aluminium plates carried by insulating bushes from the lid serve as the other coating, and the thin film or coating of oxide on the aluminium plates forms the dielectric.

Radium phenomena were displayed by Sir William Crookes and Mr. G. T. Beilby. The former scientist had a collection of pieces of glass gathered from various investigators, by means of which he illustrated the effect of light and emanations of radium upon it. Glass is affected by sunlight, but the process is very slow. Radium, however, will produce the same effects in a very short time. Glass containing manganese becomes violet when exposed to sunlight, and this tint is not superficial. Glass exposed to the emanations of radium even through quartz will assume in a few days the same tinted color that would be imparted only when exposed for years to ordinary sunlight.

The phosphorescent qualities of calcspar produced by the β rays of radium were interestingly demonstrated by Mr. Beilby. The calcspar crystal is heated upon a metal surface by electricity to a temperature of 200 deg. Centigrade. Immediately the amber phosphorescence becomes distinct. The crystal can be used repeatedly, but each time it is used the temperature must exceed that obtained on the preceding occasion. Mr. Beilby is of opinion that partial electrolysis takes place under the action of the stream of negative electrons.

There were several appliances of interest to microscopists. One was a microscope and goniometer stage devised for the examination of minute grains of sand, and an ingenious camera for taking small direct photomicrographs. This device consists of a small tube of short length which carries a projecting lens and a photographic lens. This is inserted within the camera under a tube from which the plates are dropped one at a time. The plate measures about an inch square. The tube, together with the plate, is fitted over the eye-piece of the microscope and exposed in the orthodox manner, but a special type of shutter is employed.

Electrical furnaces also constituted a prominent part among the exhibits. Dr. Harker's tubular furnace, which possesses many ingenious features, was shown by the director of the British National Physical Laboratory. This appliance is built up of rare earths. There are a number of short tubes approximating one inch in diameter contained in asbestos jackets. Contacts between the terminals and the rare earths are effected by winding platinum wires into the ends of the tubes. Platinum can be melted in these tubes by a current of 150 volts and 0.8 ampere, the melting point having been determined by Dr. Harker to be 1,710 deg. Centigrade. The electrical pressures used in connection with these furnaces range from 50 to 300 volts. The furnaces have been in use for six months at the Physical Laboratory and are in excellent condition.

Electrical furnaces constructed upon the principle of heating a carbon resistance by the passage of the current were shown by Mr. R. S. Hutton. The furnaces are constructed from various materials, including Acheson graphite, carborundum, and agglomerate carbon. In the case of the Acheson graphite furnace a hole about 3 centimeters diameter was bored through the graphite rod. The ends were screwed into heavy graphite plates which led in the current. The central part of the tube was packed round with magnesia or carbonate held in position by an outer jacket for purposes of heat insulation. The best results for the jacket it was found were obtained from carborundum. The substance was granulated so as to pass through a mesh of 180 to the inch. It was then heated and fused into a tube around the carbon, strengthening and protecting it. In the larger furnaces, where agglomerate carbon tubes were utilized, the ends were electro-coppered and the tubes were sweated into close-fitting copper sleeves. This was then surrounded by a water jacket so as to keep the exposed carbon sufficiently cool to overcome oxidation. With a tube of this type measuring 60 centimeters in length by 8.2 centimeters outside diameter and jacketed by carborundum it was found possible to obtain a temperature of 1,200 deg. C. in 30 minutes with a current of 600 amperes at 8.6 volts. Nickel can be melted in the course of 12½ minutes, platinum in 20¼ minutes, by a current of 850 amperes at 13 volts. At the end of 30 minutes the temperature continues to rise at the rate of 7 deg. C. per minute.

During the past hundred years there has been an area of agricultural development on the western border of the developed country, and this has been able to compete at an economical advantage with the older area farther east. The price of land has fallen in the East, while it has risen in the West. From 1870 to 1900 we practically doubled our population and doubled our agricultural area. Aside from the geometrical increase in the population, this development has been due to a fertile, level prairie which was practically treeless. Hitherto the axman has hewn his way tree by tree. The development of the area west of the Mississippi River is probably the most remarkable in the history of the world. A second cause for this development is the consolidation of railroads into transcontinental lines; and another is the improvement of labor-saving machinery, of which the self-binding harvester is the most conspicuous example, a machine that first attracted wide attention at the Centennial Exposition in 1876.

PLANT BREEDING.

THE knowledge gained in the early part of the eighteenth century was enlarged and somewhat improved in its scientific aspects, but was not put to much practical use until near the end of the eighteenth and the early part of the nineteenth century, when Thomas Andrew Knight, an energetic plant physiologist and horticulturist, gave the first great impulse to breeding as a method of improving plants. He recognized hybridization and crossing as the most potent means of inducing variations in definite directions, thus purposely producing changes which before were the result of chance development or which did not occur at all, and he was thus able to bring about desired modifications in a very short period of time. He recognized the slower method of inducing variation by cultivation and increased food supply, but realized that the changes that can be produced by selecting such in-

Marsyas. Veiled Muse. Winged Bacchus. Spouts of fountain. Bas-relief. Aphrodite.

HERCULANEAN MARBLES AND BRONZES PHOTOGRAPHED FOR THE FIRST TIME BY PROF. DOMENICO LOSACCO OF GIOJA.

duced variations are narrow and slow compared with what can be secured through hybridization and crossing, followed, of course, by careful selection to fix the desired types.

While there has been much advance in the scientific and practical knowledge of plant improvement in the last fifty years, we are still in the beginning of the work. In the earlier years of the nineteenth century, most of the work that was done was in the nature of a refinement of the older methods of selection. The important bearing of the work of Knight was not fully appreciated, but recently there has been a rapidly growing recognition of the importance of hybridization and crossing. If it were possible to get at the facts, we should doubtless find that much of the progress in the past has been due to chance hybridization and crossing. The best that is in a variety can be brought out by selection, but when the plant does not possess desired characters they must be introduced by combining the good points of several varieties or species, either cultivated or wild.

A good start has been made in thus combining the European and native American grapes. The production of grapes for general purposes, which has been the aim of practically all the work on grape breeding thus far, has been accomplished and even carried too far, as is so clearly pointed out in Bailey's excellent work on the evolution of our native fruits. The great need now, as there suggested, is for varieties suited to special purposes, special soils and climatic conditions, and resistant to diseases and insect pests. These may be produced by combining the desirable qualities of our wild and cultivated varieties with the good qualities of the European types.

The combination of our native American plums with the older cultivated sorts has been in progress for little more than twenty years, but many new and valuable varieties have already been produced. Hardy varieties of apples are being produced by combining the qualities of our wild crab and of the hardy Russian sorts with the good fruit qualities of the cultivated varieties grown farther South.

Similar work is being done with the orange by combining the fine fruit qualities of the Florida sweet orange with the cold-resistant qualities of the hardy trifoliate or hedge orange, which is commonly grown in the North as a hedge plant.

Very valuable varieties of the pomelo have been produced by crossing this fruit with the tangerine. These are nearly seedless and have a loose rind like the tangerine, but retain the pulp characters of the pomelo. This new fruit is called the tangelo. The small, rather dry tangerine, by crossing it with the orange, has been made larger and more juicy without losing its other qualities.

Scarcely an important fruit, flower, or vegetable can be mentioned that has not in the past fifty years been greatly improved for certain purposes through the production of special varieties by hybridization. More has been accomplished with fruits and with flower and vegetable crops than with any other classes of plants, but important advances have also been made with the cereals and forage crops by increasing yield and hardiness; and the work of the Department of Agriculture indicates that we shall be able to obtain by hybridization and selection drought resistance, alkali resistance, and resistance to rust and other diseases.

In nearly all our important crops greater improvements have been made within the last fifty years as the result of our knowledge of the causes of variation and the principles of selection and hybridization than have taken place before in historic times. This progress is the direct outgrowth of the discovery of the sexuality of plants and the laws of variation and heredity as applied to them. The physiologist is seeking to work out still more accurately the laws of variation, correlation, and heredity. When these are better understood, breeding will become a still greater power for the betterment of agriculture.

HERCULANEUM.

THE real calamity that befell Herculaneum is not to be sought in the famous eruption, which while it buried, yet preserved her. Passing down from the church of Our Lady of Pugliano, pursuing the path which leads from the foot of Vesuvius downward to Resina, one cannot but be impressed with the feeling that all those avenues and buildings lying buried beneath our feet are probably filled with priceless records of the ancient city. Perhaps those volcanic streams which inundated the helpless town preserved records which otherwise would have been destroyed by the ravages of man or of time. The more serious destruction which the buried ruins have sustained was wrought by relic hunters, who ruthlessly excavated for the sheer sake of gold. Had the lava been carefully removed by archæologists, the ancient city might have been exposed to the light of day exactly as it was when ruin came upon it. Highly to be deplored is the criminal desecration which Miguel Ruggiero describes. In the year 1709, when Prince Elbeuf accidentally discovered the theater, Ruggiero tells of an uninterrupted series of shameful pillages. Moreover, engineers, beginning with Alcubierri, dug out the site, and used the material thus obtained in the erection of buildings. Houses were demolished, statues were mutilated, and excavations filled up with their fragmentary arms and bodies, thus burying anew the plundered edifices. Then followed that unpardonable order issued by Paderno, "to level to the ground those useless painted old stones and heaps of frescoes." The very varnish invented in 1739 by Moriconi, an officer appointed for the preservation of these frescoes, was covered with a thick layer of yellow plaster. The artisans intrusted with the restoration of the bronzes painstakingly scraped off the patina, that rich green which only centuries can give, and the Directory gave orders to have them melted over into madonnas and candelabra.

And yet there may still remain works of exquisite beauty. The museums of Vienna and Prussia contain relics which were spared the ignominy of transmutation to madonnas or complete destruction. The houses and buildings from which they have been taken are known to us only from the testimony of those who were present at the time when the relics were removed. Archæologists wonder where that basilica may be with its columned peristyle, which proved so rich a mine. Ruggiero took it for a court, while Beloch held that it was a true basilica, or perhaps an assembly hall rather than a forum, richly adorned with demi-gods and combatants, its walls all painted with eagles. Archæologists wonder also where may be the temple of the Mother of the Gods, of which some writers speak, with its vault of pure white glittering with innumerable stars. There was also another temple, Ionic in architecture if one may judge from the accounts that have come down, in front of which a fountain splashed, spraying the statue of a youth riding a dolphin. The greatest of all of these structures is the magnificent villa of the Pisoni, with its vast terrace overlooking the sea and literally filled with riches of all kinds. The city, as Nissen has described it in his "Italische Landeskuenste," surprises us by its symmetrical plan, the ample breadth of its streets, and its architecture. M. Beule, in "Le Drame du Vesuve," a charmingly inaccurate book, draws a parallel between Herculaneum and Pompeii. The population of the former was Greek; that of the latter Oscan. The one was devoted to intellectual culture and the pleasures of elegance; the other was a commercial community. One may indeed conceive Herculaneum as a place of delight and of refined intellectuality, and the most typically Greek of Campanian towns.

Writing in L'Illustrazione Italiana, Francheso Pata gives a rather florid account of a visit which he paid to the old town. From that account we excerpt the following paragraph:

"The custodian kept at Herculaneum by the government took the customary two diminutive lanterns. I wished they had been torches, because their flickering light animates the scene with dancing shadows. With these pale little lights to guide us we descended the lava steps, indented with hollows, that are now mud puddles. The visitor feels above his head roots of trees that have penetrated the soil from gardens overhead. Insects have taken up their abode in the dark passages. Water drips down. These places are oppressively close as we tread the broad slabs of lava.

Entering the mutilated houses, whose roofs are now the clouds, we have more than ever cause for regretting their violation. In the structure called the House of Aristides, the remaining frescoes are fast fading. On the walls there are well-nigh invisible pictures of the Sacrifice of Dirke. Next comes the House of Argo, ornamented with silver citherns and small satyrs. In the halls may still be seen large clay posts, which supported the stone benches. The niche of the household gods, the inner court with its waterless fountain, may all be seen, and there is also to be found more than one mark of the devastations committed by the soldiery of the eighteenth century. The baths too are still intact, and likewise narrow walls that may once have served for horses, if one may judge by the bones that have been found in them. The baths have been only partially uncovered, and extend far down under the ramshackle huts of modern times, their gutters clogged with a mass of rubbish and loose stones."

CURIOSITIES OF A SEED-WAREHOUSE.*

By CARNOCHAN DOUGLAS.

THE remarkable tulip-mania which swept over Holland three hundred years ago, when the cost of bulbs rose above that of the most precious metals—as much as four thousand five hundred florins being paid for a single root—still remains without a parallel in the history of gardening. Nevertheless, far larger sums change hands in a season over simple seeds than the outside public, however devoted it may be to the art of gardening, has any idea of.

Take the innocent sweet-pea, for instance. Who would believe that, of the better varieties, an average wholesale price for its seeds may be estimated at from one hundred to three hundred pounds per ton; and that anywhere from fifty thousand to one hundred thousand pounds would represent the output, wholesale, in one season alone? A specially choice novelty would command at least five pounds per ounce retail—which would total out to one hundred and seventy-nine thousand two hundred pounds per ton, if such a quantity were ever required. This is a truly astonishing figure—an ample fortune for many a man.

As compared to these, we find the cost of the cheaper varieties of seeds—say, the common convolvulus—would probably amount to only fifty-six pounds per ton wholesale.

Even so, the vegetable and agricultural seeds vary in representative money value: cauliflower, onion, celery, parsnip, mangold, swede, turnip, clover, and grass seeds all differ in price according to their quality and novelty.

It is obvious that the enormous quantities of seed required are not grown within the British Isles; they are gathered together from every corner of the world, and the intermediary between the grower and the retailer or market-gardener is the wholesale seed-merchant.

The heads of these wholesale houses are not known to the general public. Advertising in any form is as strictly tabooed as it is by the members of the Royal College of Surgeons; the retail houses only may advertise to their heart's content.

The bulk of the seed imported is temporarily stored in large warehouses, whose mysteries are strictly guarded and inaccessible to the outsider.

The flower-seed department alone of one of these large depositories occupies a whole building consisting of a basement and four floors. The ground-floor is entered through massive double iron fireproof doors, which effectively protect it from fire and thieves.

In the center of this floor are large bins filled with seeds, mainly sweet-peas; while round the sides run long fixed counters where men are busily employed, one of each couple weighing out the quantity ordered, while the other puts it into seed "pockets" or brown-paper bags, according to the size required.

Behind these workers the walls are lined with innumerable drawers filled with loose seed. These contain every known variety of flower seed carefully labeled each with its Latin name. Some of these drawers, when filled with choice kinds of seeds, such as primulas and cinerarias, represent an enormous money value. One pound of such seed would cost from one hundred and thirty to two hundred pounds wholesale; or a choice petunia-seed, for example, would range at about ten pounds ten shillings for a single ounce.

On the next floor, in place of the drawers of seed, part of the walls are filled with pigeon-holes, into which the packets of different varieties of seeds are put. At the counters in front of the pigeon-holes men and women are engaged rapidly filling and making up the packets, which are placed in the holes ready for dispatch at a moment's notice.

The center of the floor of the third story is piled high with sacks to replenish the drawers and bins on the lower floors. Here are bales and bales of nasturtium-seed from Great Britain and the Continent; tons and tons of sweet-pea seed from California; also tons of mignonette-seed harvested on the banks of the Loire, the native land of Margaret of Anjou, queen of our Henry VI., or grown on the fields near the Bodethal, in the neighborhood of the fairy-haunted Brocken; while the rest was harvested in Essex. In addition to all these, there are innumerable bags of marigold and eschscholtzia seed.

On the shelves that flank the sides of this granary are placed smaller-sized bags containing costlier varieties of different seeds—one with six and a half pounds of a choice variety of pansy, representing a money value (wholesale) of eighty-four pounds. Asters are there in endless variety, for of these seeds some growers order as many as twenty pounds to be used for cut flowers alone.

A large portion of the top floor is covered with bags of seed piled high to the ceiling, which are likewise used to replenish the stock on the lower floors. The more interesting portion of this story, however, is that part partitioned off with strong wire-netting and securely locked. Behind this stout barricade are kept what are known as the stock seeds of the firm. These seeds have been carefully selected and improved on the firm's own trial-grounds, to insure that the seed for disposal one or two years hence may be of the very best strain. These are sent to those countries whose climates are best suited to their reproduction and their products, and received back after harvest. Before the seed thus obtained is allowed to pass into the hands of the retailer it is once more tested to see if its growth is perfect.

As in the case of famous racehorses, the pedigrees of these precious stock-seeds are carefully preserved in large, heavy-locked ledgers, so that the family tree of each class of seed may be readily traced back through generations of ancestors. This is a highly important and intricate part of the detail of the business.

The trial-grounds on which these test results are obtained are likewise replete with interest. The seeds to be tested are sown in short rows, each row being numbered, and a full description kept in the firm's books. When the blooms have reached maturity they are examined as to color, habit, size, etc., and should any "rogues" be present they are carefully noted in the firm's trial books.

In another warehouse there is to be seen a large staff busy with the execution of orders for bulbs. These also had traveled far and wide ere they reached the heart of foggy London. The bulk came from Holland; for instance, such hyacinths as Czar Peter and La Grandesse, with their gorgeous scented blooms, or the stately *Tulipa gregii*, and delicately tinted Murillo tulips. There are, however, also lilies from Japan, freesias from France and Sicily, beautiful ranunculi from Italy and Anjou, not to mention narcissi from the Channel and Scilly Isles, tuberoses from the United States, and lily of the valley from Germany.

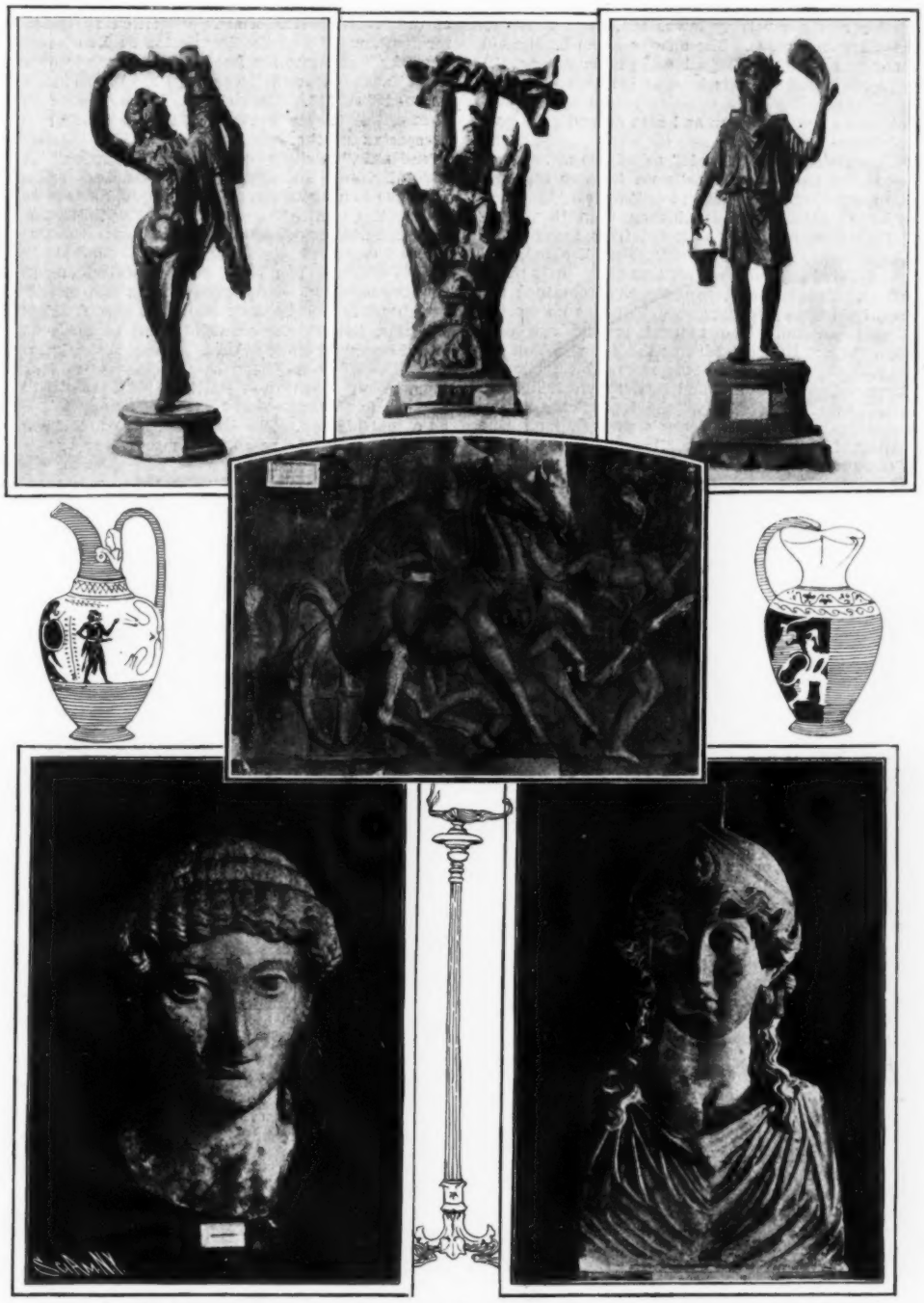
The vegetable department is equally fascinating. For example, Rochfort's Market, one of the choicer varieties of cucumber-seed, has a wholesale value of about eighteen shillings per ounce, or thirty-two thousand two hundred and fifty-six pounds per ton—if such an immense quantity were required by any individual, which is never the case.

When we realize that one ton of this seed might, on an average, produce something like seven hundred and sixteen million eight hundred thousand cucumber plants, we may have some faint idea of the truly appalling and colossal vista of indigestion for which it would be responsible should an unwary public have no proper regard for its *petites Maries*.

Cauliflower-seed is here in abundance, and not less interesting from the fact that it has been grown on the slopes of Mount Vesuvius, and fertilized by the lava poured out in past ages, possibly even by that which engulfed historic Herculaneum itself.

Tiers and tiers of sacks are piled high up on this floor, all filled with broad beans, the greater part of the early varieties of which have been grown near Seville or on the plains of Italy. Quantities of peas of all varieties are collected on another floor, hundreds of tons of the seed of this favorite vegetable passing through the building in one season. Hundreds of bushels of these have come the three months' journey by sailing-vessel from New Zealand; others have been brought from Canada; others again have been harvested in the fertile plains of Germany near the Hartz Mountains.

Elsewhere are stored immense quantities of the scarlet-runner bean. How little the amateur gardener,



Victory bearing trophy. Aphrodite. — Hand in pose for taking oath. Two-wheel chariot guided by a Moor. — Youth with bucket and flabellum. Pallas.

HERCULANEAN MARBLES AND BRONZES PHOTOGRAPHED FOR THE FIRST TIME BY PROF. DOMENICO LOSACCO OF GIOJA.

* Chambers's Journal.

when he invests threepence in half a pint for his garden, knows about his purchase, or realizes how far these beans may have come! There flashes through his mind no picture of the districts in far-away Galicia, behind the Carpathians, where they have been harvested. The work of farming and harvesting these beans is done mainly by peasants quaintly dressed in their native garb of sheepskins, who cultivate small portions of ground. After harvest these men flock to the local markets, each with the produce of his small plot of land, which he disposes of to the buyer. The buyers, chiefly Jews, make a good profit as middlemen between the peasant cultivators and the British wholesale merchant, and hundreds of bushels of beans are thus sent *via* Danzig and Hamburg to London. In a lofty granary are piled quantities of radish-seed, of which some growers plant as many as twenty bushels. How insignificant seems the ordinary ounce one buys when compared with this! Close by are stored tons of the seed from which our favorite spring onion is raised, and which claims southern France as its home.

It is wonderful to note the care necessary for the production of those velvety lawns for which the British Isles are so famous. The answer given by the old gardener at one of the Oxford colleges to the American who asked him for his lawn-recipe does not quite suffice.

"You cuts un and rolls un and cuts un and rolls un," replied the old man.

"Is that all that is required?" asked the stranger.

"Ye-es, just cuts un and rolls un for two hundred years, or more, and you gets your lawn all right."

Something more is required than even this, however. The seed has been collected from many countries. Germany, Holland, Canada, New Zealand, Ireland, and the county of Kent all contribute their share toward it. The different samples thus obtained are thoroughly cleaned and "screened," so that no foreign weed may remain. The natural grasses are then mixed with just as great care as the tea-merchant devotes to the blending of his teas or the chemist to the making-up of an important and intricate medicine; indeed, the sheet descriptive of the ingredients resembles nothing more than a doctor's prescription. The quantities of each variety are all accurately specified and the names written in Latin (Latin, be it said, peculiar to the seedsman, and scarcely admissible in classic circles).

Another interesting department is that of the pea-pickers. About a hundred women are employed for the work. They are seated in rows at desk-shaped benches, and bright and happy they look working away as their tongues keep tune to their hands. Rapidly they pick out the bad peas and allow the good to fall through a hole in the desk into a bag beneath. This bad seed, when carefully separated, is used for feeding purposes. In an ordinary way these women pick from five to six bushels per day; but should the peas be weathered, as in the last season, it might take two days to pick a single bushel.

Wonderful to tell, the seedsman has also his incubator. In a room at the top of one of the buildings are found hundreds of small pots containing growing seeds. These are tests to ascertain whether or not the seeds will really grow, and in this way every lot of seed which comes into the warehouse is at once sampled—that is, fifty or one hundred seeds are counted out and placed in the testing-chamber. The results of these growths are recorded in a book, and later transferred by the testing-man into the large locked ledgers which have been already mentioned; thus percentages of the growths are obtained.

To prove the correctness of these results, a duplicate sample of seeds is put into an incubator, much after the fashion adopted by the scientist to propagate his bacilli. The seeds are wrapped in blotting-paper, then put on thick sheets of the same, and placed on zinc trays; they are then thoroughly damped and left in a hot chamber to germinate, which takes about two days. The necessity of the portly pedigree-books becomes at once apparent, because no matter what information is required, they can give it all. At a glance one can see what quantity of stock exists, where grown, and from what parentage.

The busiest time in one of these warehouses is naturally from November until February, when enormous quantities of seeds and bulbs pass through the buildings, and any one who is then lucky enough to obtain permission to visit one of these closely guarded depositories, teeming with interest, will scarcely regret the hour thus spent.

SOCIAL PIONEERS OF SCIENCE.

By T. H. S. ESCOTT.

"I CARE nothing about *homo*, Huxley, except as a creature of historical tradition." "And I, Hannay, care nothing about *homo* except as a compound of gas and water. But if you and I were better educated men than we are, we should know how to respect each other's studies more." Such was the little fragment of dialogue between two typical representatives of different intellectual cults which (being in their company) the present writer happened to overhear on the steps of the British Museum some time during the sixties of the last century. The Edinburgh Courant had been founded in the Whig interest by Daniel Defoe. More than a hundred years later it became a convert to the picturesque and feudal Toryism of Sir Walter Scott; under that dispensation it had as its last editor of any considerable distinction the clever littérateur who wrote two sparkling novels of the Captain Marryat school, "Eustace Conyers" and "Singleton Fontenoy." Hannay's admiration of "blood" as an historic force was only less fervent than that of the weak-eyed young man who, at Mr. Spenlow's feast in "David Copperfield," took "Hamlet's Aunt" in to dinner; his "blood and culture" enthusiasm was the subject of many jokes. James Hannay also showed himself a spirited historian of the unphilosophic and pictorial sort in his book on the Gurney family, signally combining, as that did, honest reading and original thought with a fine literary instinct and a natural aptitude for happy expression.

Hannay's place in *belles-lettres* may be compared to that of another ex-sailor, the Frenchman best known by his pseudonym, Pierre Loti. Both men prepared themselves for the profession of authorship while they "occupied their business in the great waters." Each, under not entirely dissimilar circumstances, prematurely quitted a nautical life. The earliest writings of both are suffused with local color, drawn from their maritime experiences. In literary criticism and on literary subjects generally, Hannay made his mark, not only as a Quarterly Reviewer, but elsewhere on the periodical press; his "Satire and Satirists" brought him a request from Thackeray that he would annotate a new edition of the "English Humorists." "Written by Gentlemen for Gentlemen" was the description said to have been given by Hannay to the London newspaper to which he was attached before going as consul to Barcelona, where he died in 1873. Hannay may have gloried in the phrase, but it was not his. The words occur in the prospectus of the imaginary "Pall Mall Gazette" of "Pendennis," written by "Captain Shandon" in the Fleet Prison. Hannay received his consulship, not from the fourteenth Lord Derby, whose literary as well as racial qualities he adored, but from his son, the foreign minister whose accomplishments Hannay had himself described as belonging to the "mechanics' institute order." The boast of that statesman's father that he belonged to the pre-scientific age might have been truthfully echoed by Hannay himself. This fact contains, indeed, the sum and point of the conversational fragment quoted above. After practically grounding himself in medicine at Charing Cross Hospital, Huxley, on board the "Rattlesnake," practised as a surgeon in the same fleet in which Hannay had served as a midshipman. The two men, separated by an interval of only two years, began their London careers about the same time. Though not in equal degrees, both at the date of their British Museum conversation were among the men of the time.

The popular taste for Addison's and Steele's essays was the product of the coffee-house. The French traveler Thevenot, in the middle of the sixteenth century, brought from Constantinople, where the first establishment of the sort existed, the idea of the coffee-house to Paris. Before then, however, the institution had been firmly planted, not in London, but in provincial England. Among the undergraduates of Balliol College, Oxford, in 1641 was a certain native of Crete, by name Nathaniel Canopus, who could not stomach for breakfast the small-beer which was then the morning tipple of the place; he produced a tin of coffee given him by a Syrian friend. A college scout of the period, having brewed the beverage for his employer, tasted it himself, found it very good, and gave some to his friends in the buttery below. The fame of this most excellent substitute for the college ale reached the Master and the Fellows, who, between 1645 and 1650, discussed cups of hot and fragrant Mocha round the Balliol common-room. While Canopus was revealing the new drink to the college of Wycliffe, an Oxford townsman, a Jew named Jacobs, was opening the first coffee-house possessed by England as nearly as possible on the spot now occupied by the London and North-Western Railway station. The keeper of that place of entertainment retailed the berry in its best quality for consumption off the premises; probably he had supplied the gownsman Canopus when the stock brought by that gentleman from eastern Europe began to run short. Canopus seems later on to have entered into a sort of partnership with the coffee-selling townsman; for, during the second half of the seventeenth century, Messrs. Canopus & Jacobs were appointed purveyors of coffee to a little club of scientific Oxonians presided over by Dr. Wilkins of Wadham, and meeting twice or thrice a term in his rooms.

This coterie was known by the name of the Philosophical Society of Oxford. Amalgamating with London savants, some of whom, like Wilkins and his friend Wallis, soon afterward settled on the Isis, it formed the nucleus of the Royal Society. Both at Oxford and in London, whatever the place of meeting might be, the scientific usefulness of the gathering was extended by its investment with social attractions. Solid refreshment was not furnished, but an abundant and gratuitous supply of their non-intoxicating beverage was provided by Messrs. Canopus & Jacobs. The intellectual temper of English society seems to have been scientific rather than literary till quite late in the Georgian era. The "First Gentleman in Europe" had been trained in an atmosphere of the conventionally classical and literary kind. The wits whom he had gathered round him at Carlton House or the Brighton Pavilion resembled their royal patron in disliking any intellectual exertion which might bring into play a new set of muscles of the mind. Charles James Fox, indeed, to do him justice, possessed a good deal more than merely the clever schoolboy's familiarity with Latin and Greek. Samuel Johnson learned Dutch late in life as something to "grind his mind upon." Fox, like his royal master, would have shirked any such disciplinary use of linguistic study, and, in fact, so detested whatever involved abstract thought that he would not take the trouble to read so epoch-making a book as Adam Smith's "Wealth of Nations," or even to understand the rudiments of English finance.

Droll as it seems, the prejudices and partialities of the macaronis and fribbles of the Regency period had something to do with setting the intellectual fashion for many years after the very nicknames of these dandies were forgotten. The court under George IV., and to some extent under his successor, reflected the literary temper of the rakish Whig leaders. The fourth George himself knew almost as much about Theocritus and Virgil as his favorite statesman. An educational reformer, incredibly in advance of his time, happening to find himself at Court on the day that Dr. Keate had been sent for to Windsor Castle, hinted to his sovereign that the Eton boys might receive occasional lessons in the applied sciences. The sovereign frowned disapproval on the presumptuous suggestion; the head-master characteristically barked out in an undertone that he should have liked to flog the man who made it on the spot. Neither the king, however, nor the arch-bircher could prevent or ignore the fact that the social tide was setting in favor of science as a recognized part of English culture. After the Royal Society for Advancing Natural Knowledge (so styled in 1662 by its founder, Charles II.) had ceased to meet at Gresham College, it found its headquarters at Arundel House. A member of its host's family presented it with a valuable library. Other donations and legacies followed. It began to be a wealthy corporation. In 1710 it was domiciled in a house which it had purchased in Crane Court.

Long before the eighteenth century had come to an end polite patronage had done much toward assuring for a knowledge of nature and its laws a recognized place in the educational course. Richard Lovell Edgeworth (1744-1817), by his turn for mechanical inventions, was led into deeper inquiries as well as into an intimacy with Dr. Darwin, the great scientific pioneer of that period. Edgeworth impressed on his daughter, the more distinguished Maria, the value of natural philosophy as an instrument in training the youthful mind. Miss Edgeworth's novels and stories, without professedly fulfilling any scientific mission, are written in a scientific tone, and in innumerable passages, as much by what they suggested as by what they said, were calculated to stimulate a popular interest in physical inquiry.

A relation of the Edgeworths, honored as a west of England worthy, Thomas Lovell Beddoes, is still locally, if not nationally, remembered as an active propagator of the new learning. Dying in 1849, he must in life, to judge from his portraits, have looked like the prose original of Dr. Dulcamara on the burlesque stage. His habitual costume was nearly that worn by Toole in the part of Paul Pry. The chief interest attaching to Beddoes comes from the fact that in his "pneumatic institute" at Clifton he had for his assistant a Cornish lad fresh from a Penzance surgeon's dispensary, Humphry Davy. Coleridge and Southey, then often in the neighborhood, were the most interested and regular witnesses of his experiments. "That boy," said Coleridge, pointing to the future inventor of the safety-lamp, "will go a good deal farther than his master." Southey's observation of natural philosophy incidentally proved more useful even than Coleridge's. Southey, indeed, did not become a real power on the Quarterly Review till some years after his first acquaintance at Clifton with Beddoes and Davy. But in John Murray's Albemarle Street parlor he was in the habit of meeting the editor Gifford, as well as his chief writers. These latter affected a contemptuous indifference to physical science in all its branches. Zinc wire, gas, water, and liquid manure were said by George Canning the Minister, as by his friend and literary collaborator Hookham Frere, to be the only matters on which science could possibly help its votaries. Fresh from his Clifton experiences, Southey had the courage to differ from his editor and his associates. "This new knowledge," he said to Murray, "is steadily creating a new literary demand that must be met." The remark was soon followed by condescending references to natural inquiry in the Quarterly Review, and by the publication of popular handbooks on natural philosophy, and so forth.

The opening of the nineteenth century saw Davy's lectures at the Royal Institution animate London with an enthusiasm for the subjects on which he discoursed. Gradually the savant became a lion in society as well as a teacher in the lecture-room. First Sir Humphry Davy, then his pupil and assistant Michael Faraday, were in high request for fashionable drawing-rooms. Lady Blessington did not consider her Gore Lodge receptions complete without one of her open-air philosophers, as she used to call them. Fugitive pieces on more or less scientific themes now commenced to mingle with the literary contents of the keepsakes and albums edited by ladies of quality, like Lady Blessington herself. The exquisites of the old literary caste did not like it. Hence the words attributed to Count d'Orsay when some one spoke to him about vegetable products: "Yes, I think I once took a pea." About this time, too, certain associations of personal romance really operated as pioneers of science with the public. There has come up a second "lion out of Judah"; so said Charlotte Brontë, who had already given the leonine description to Thackeray on the first occasion of her seeing Michael Faraday. The facial resemblance between the novelist and the philosopher was remarkable. The dramatic vicissitudes of Faraday's life; the simple beauty of his character; above all, perhaps, a general impression that his chief, Sir Humphry Davy, now very prosperous, and some thought rather pompous, owed to his pupil more than he cared to acknowledge, had created a deep interest in the great electro-magnetic researcher, who had begun life as a bookbinder's boy in a back street of the West End.

When the present writer's London life began, a little more than a generation ago, the talk in literary circles

often used to go back to the weekly gatherings held over a publisher's shop in the Strand. These premises belonged to the Chapmans, who were the first publishers of the Westminster Review. Mr. Herbert Spencer then wrote for the Daily News, and for a little weekly paper owned and edited by his friend Edward F. S. Pigott, whose interest in all departments of intellect was as comprehensive as it was keen, and who is known to the present generation as the late censor of plays. Hither also came George Henry Lewes; it was the talk heard by him here which put into his head the notion of a history of philosophy written from the severely scientific point of view. Here also Lewes met Mary Ann Evans for the first time. At the Chapman gatherings, also, the lady herself contracted her earliest intimacy with science, a taste for which, growing with her mental growth and strengthening with her mental strength, did not perhaps prove entirely favorable to George Eliot's literary art. But here it may be pointed out that long before the "Scenes of Clerical Life" announced the advent of a new genius of the pen, the leaven of scientific thought and diction had begun in Charlotte Brontë's novels to influence contemporary letters.

On Michaelmas Eve, 1868, died Henry Hart Milman, Dean of St. Paul's. I recall the exact date because not many days previously I had made my début as a London diner-out at his hospitable board in the Deanery. The most interesting, as well as the best, talker among the guests struck me, I remember, as being the geologist Sir Charles Lyell, then just a septuagenarian, with a manner made up of urbanity and distinction. "I have," he said, "just returned from a visit to Oxford, where I find the undergraduates are educating themselves to believe that the Jews, possessing a genius for religion, just as the Greeks had for literature or art and the Romans for law, invented the whole contents of the Old Testament first, and of the New Testament afterward." The blending of the personal and the anecdotal with the scientific in Lyell's conversation at Dean Milman's table was singularly happy and delightful. I happened to mention a recent visit I had paid to Paris. "Ah," said he, with, I thought, a stronger Scotch accent than he had yet used, "Paris is well enough in its way; but, as my old friend Robert Chambers, quoting one of his countrymen, used to say, 'For pleasure give me Peebles.'" This remark led to another about the anonymous "Vestiges of Creation," whose appearance had been one of the sensations previous to my own birth, and, from a literary point of view, certainly comparable with that excited by the nameless Waverley Novels. "It was," said Lyell on this occasion, "one of those works that mark eras. Without it the public mind would not have been fitted to receive Darwin's 'Origin of Species,' published fifteen years later."

Lyell knew that I came from a west of England stock. "We have each of us," he went on pleasantly to say, "something to be proud of from the physicist point of view. Humphry Davy, the Cornishman, and Andrew Crosse, the Somersetshire squire with a turn for electricity, were not less necessary to what is known now, and above all to the popularization of that knowledge, than were my own two compatriots, Hugh Miller and Robert Chambers." Andrew Crosse, of Broomfield, had gone long before my entrance into this world; but his personal fame, in my childhood, lived in his country and mine. I myself have seen, in the grounds of his former house in the Quantock country, the electric wires, attached by him to the trees, conducting illuminating streams beneath his roof; thus by a distinguished man in a remote region was the electric light anticipated in the heart of an unscientific age. On this occasion of my meeting him, I think I understood Sir Charles Lyell to say he had actually heard Andrew Crosse make his famous prediction: "I prophesy that before the middle of the nineteenth century we shall be enabled to communicate our thoughts instantaneously with the uttermost ends of the earth." There were many social prejudices for Crosse to overcome. Something more than a suspicion of uncanniness attached to his pursuits. His humbler neighbors, even the domestics of his own household, looked askance at his workroom as the chamber set apart for his assignations with the powers of darkness. His neighbors in that exceedingly Tory countryside looked upon physical science in any shape as a dangerous mode of destructive Radicalism, somehow connected with and growing out of the French Revolution. No man in his generation did more to disarm these prejudices than Andrew Crosse, and to reconcile the genteel philistinism of his generation to the study of natural agencies as a blameless, and possibly even a beneficent, branch of knowledge.

Huxley, of the square, straight figure, the fine brow, the clear and remarkably expressive eyes, in other ways than by his historic appearances at the British Association meetings or his work at the School of Mines, socially befriended the cause of natural knowledge. A better writer than he was speaker or talker, he showed for the first time that a man might give his best years and energies to physical inquiry and yet yield to few of his contemporaries in purely literary accomplishments and distinctions. Something of the same sort, though of course in a much less degree, may be said of a clever writer not long since dead. While at St. John's College, Oxford, H. D. Traill, as a student of the Humanities, was a favorite pupil of the rhetorician and metaphysician who eventually succeeded Milman as Dean of St. Paul's. H. L. Mansel, besides being a philosopher, had an extraordinary gift of literary parody and caricature. Traill was the disciple to whom this teacher most signally imparted his own most attractive acquirements. Yet Traill, having taken a first class in the purely classical school of Moderations, directly the academic course left him free to choose his studies, went in for the Natural Science School. That school, throughout the sixties of the nineteenth century, was a comparative novelty; it owed existence and early popularity to the geological professor Phillips, to Sir Henry Acland, and particularly, I should say (looking back on my own experience), to the stout presence, the strong mind, and the genial bearing of George Rolleston. "Bones and stinks" was the unflattering vernacular by which unscientific youth indicated this new branch of learning. The men just mentioned, whether as successful students or as persuasive teachers, popularized it with a rapidity which fifty years ago none foresaw.

With another Oxford savant, Henry Smith, the mathematician, Fellow and Tutor of Balliol, must be associated the recent great increase in the attraction to intellectual persons of scientific study. In 1842 Darwin seriously prepared for the great work of his life by settling at Down; his house became the social rendezvous of able and thoughtful men of the world, who found refreshment from their secular labors in the company and pursuits of their host and teacher. Conspicuous among these visitors were Sir John Lubbock and Sir Mountstuart E. Grant Duff. Eventually the former became Darwin's neighbor by settling at High Elms, Farnborough; the latter, after some rural migrations, bought the Orleanist villa, York House, Twickenham. The two men took the same interest in the entire world of physical phenomena; they were frequent visitors at each other's houses; they received an equal number of cultivated guests beneath their own roofs. The Lord Avebury of to-day has never lost in the philosopher the easy and agreeable manner of the polished Etonian. Grant Duff, more recently the Governor of Madras, always united with his scientific interests a knowledge of the inner life of politics and personal ways of statesmen, which made him the most entertaining or instructive of hosts, not less than, in Dr. Johnson's phrase, "the most clubable of men." Mr. Gladstone was only one of the regular political visitors at York House who, even in spite of a natural prejudice against science, gradually found themselves inoculated with a scientific appreciativeness. These lines have been written since John Morley's "Life of Gladstone" appeared. There has been much inaccurate conjecture as to how and where the statesman met his future biographer. It will be of some permanent politico-literary interest if the present writer places it on record that this meeting took place on May 18, 1879, in the drawing-room of Sir M. E. Grant Duff's Thames-side residence, York House, Twickenham.—Chambers's Journal.

THE PHYSICAL PROPERTIES OF ICE AND WATER.*

WE know that ice is very plastic; it can be molded into various shapes. We have examples of ice which has been pressed between heavy molds to form perfect spheres; and ice that is pressed in a cylinder may be forced out of a narrow opening. Ice, however, does not exhibit the characteristic properties of viscosity. This was pointed out by Tyndall. An illustration of this is the glacier action. A glacier in moving from a narrow passage to a wide passage cracks instead of adapting itself to the wider passage. A glacier moving down over a very gentle slope will crack on lines at right angles, showing that ice is exceedingly brittle. Therefore, we cannot say that ice possesses viscosity to any great extent, although it can be molded under pressure and made to run under pressure. Now the phenomenon which enables it to give under pressure is probably due to another physical property of ice, namely regelation. We know that pressure sufficiently great will melt ice. One hundred and fifty atmospheres pressure will lower the freezing point of water and ice one deg. C. It does this by squeezing some of the ice back into water; the temperature is lowered by the melting of the ice and the absorption of the heat. Regelation accounts for a great many ice phenomena of nature. A very beautiful example of regelation is Bottomley's experiment. It is a block of ice being cut through by a wire attached to a weight. I dare say many of you have seen the experiment. The pressure of the wire at the point of contact melts the ice. The water runs around the wire and finds itself freed from the pressure and at a temperature lower than its freezing point; it freezes again above the wire. In this way the wire slowly creeps through the ice, leaving it as strong after the wire passes as it was before. By means of pressure we can freeze blocks of ice together—two pieces of ice brought together and pressed will stick together. A slight film of water is formed on the touching surface, and immediately the pressure is relieved the water in contact with the ice surface finds itself below the normal freezing temperature, at once solidifies, and cements the two blocks together.

There is another property which ice possesses and which has quite recently been measured. That is, it possesses the power of growing by itself; ice in contact with water exactly at the freezing point apparently goes on growing. You have all observed the beautiful growth of a crystal of alum or a crystal of sugar in a saturated solution of the alum or sugar, and how it gradually increases in size. Apparently ice does the same thing, only very slowly. Water possesses ice in solution. The rate of growth of the ice crystals has been measured. If we allow the natural rate of growth to go on it would form an inch in about two and one-half years. So it does not form a very important factor in practical engineering problems. It forms an important factor, however, in this respect, that it helps to cement ice crystals together. It was Faraday who first showed that if we had some cracked ice floating in a vessel, by taking one of the pieces of ice and bringing it in contact with another piece of ice it would stick to it—no pressure required, merely contact—and would draw it along. So he was able to get a whole train of six or eight pieces of ice in a vessel all being led by the first piece. This process of growth shows why these particles cemented themselves together when touched. For at the point of contact we have two ice surfaces with zero water between. The ice would be growing all the time and hence the two pieces in contact would at once adhere. A pressure is therefore not required to cause ice to freeze together.

Now of the physical properties of water we have the most important, i. e., maximum density. We then have the facts that water is opaque to heat rays and that it allows only a few of the heat rays to pass through. We have a further and quite an important physical property, that below 40 deg. C., or about 97 deg. F., water commences to form ice; this ice remaining in the solution until the freezing point is reached. The proportion of ice increases as the temperature falls, and at the freezing point we have actually a saturated solution of ice and water. It explains to us the maximum density of water and the minimum specific heat.

The curve showing the variation of the specific heat of water drops very rapidly from 0 deg. C. and passes through a minimum at 40 deg. That is apparently due to the fact that besides the heat absorbed in the natural expansion of the water we have the heat absorbed in transforming those ice molecules into water molecules. That is as the temperature rises, the amount of heat that would be absorbed by the ice becomes less and less. At 40 deg. C. we have an exact balancing. From 40 deg. upward we have the water existing as a pure liquid.

I have taken up the chief points in regard to the physical properties of ice and water with the exception of the great change in volume that takes place when water freezes, which has such an important influence in river ice formation. There is an increase of about 9 per cent in volume, and this is exceedingly important inasmuch as the ice as soon as it is formed comes to the surface or remains on the surface. Take for example a sheet of quiet water which is cooled lower and lower by the advent of winter weather. The surface becomes cool; the cooler layers fall to the bottom until 4 deg. is reached. Then the warmer layers stay at the bottom and the cooler layers remain on top. As soon as the surface gets to the freezing point ice forms. This ice spreads over the surface, usually from the banks toward the center, and gradually increases in thickness by conduction.

To the convection of air currents we probably owe the fact that the ice spreads from the edges to the center, because the water heats the air and it therefore rises from the center and colder air sweeps in from the banks to the middle. We therefore have the water along the edges always in contact with colder air than at the center. It has been considered that conduction plays probably the most important part in this phenomenon. But the conduction of heat through the banks of the river is slow indeed. It is so slow as to be practically negligible.

Let us consider what goes on in the case of a river which is flowing too rapidly to form a surface of ice. Naturally we will have instead of the flat surface ice ice of finer quality formed. Each little piece of ice produced by the cooling of air on the surface is carried down by the currents and submerged, rising to the top again as the currents carry it above. Not forming the protecting layer of ice the flowing river loses a very much greater amount of heat and the fine ice is produced by agitation in very great quantities. This is to be expected if we stop for a moment to consider river ice formation. How is this heat taken away from the water? We have the three governing processes at work. Conduction is probably negligible; convection by means of air currents and radiation from the water which is warm compared to the air above it.

These fine crystals of ice which are formed, and which are called frazil crystals, are swept down with the current, and are carried by the current for long distances from open water under the surface ice. It was one of the discoveries of the Flood Commission of Montreal that this ice was found many miles below the bordage ice at the foot of the Lachine Rapids, where the greater portion of this ice is formed. An inspection of the many diagrams of the Flood Commission for various sections of the St. Lawrence River below the city of Montreal, shows immense accumulation of frazil or what the engineers have called also sponge ice. It was found on examining this ice that it was very spongy. In determining the depth of the ice a leaded weight could be lowered through by slight pressure from above, and it was found that this ice accumulated under the surface ice to depths ranging from 30 to 35 feet. That it acted as a filter to the water which penetrated it was shown by the accumulation of a great deal of matter from the water, just as a sponge accumulates slime from water. The great bulk of this ice which they found was manufactured in the Lachine Rapids, and in the reaches of open water extending about six miles from the ice sheet on Lake St. Louis. They found in many places below the rapids that there was more ice than water. The percentage of this ice became less as they obtained their suctions further and further below. Until finally, some twelve miles below, the frazil was exceedingly

* Abstract of a paper read before the American Society of Mechanical Engineers by Dr. Howard T. Barnes.

scarce. In general, wherever an open river flows unprotected, quantities of this frazil ice are formed by radiation and by convection of air currents and wind agitation. These crystals of ice vary in size, depending upon the agitation of the water. The more rapid the agitation the finer they are, and the further they travel the larger they grow.

There is another form of open water ice which we must consider, namely, anchor ice. Anchor ice and frazil ice are often mistaken for the same thing; as a matter of fact we must distinctly draw a line between the two. Frazil ice is formed in the water itself by surface agitation and other causes. Anchor ice is ice that grows on the bed of the river, on the rocks, on anything in the bed of the river to which ice may be attached.

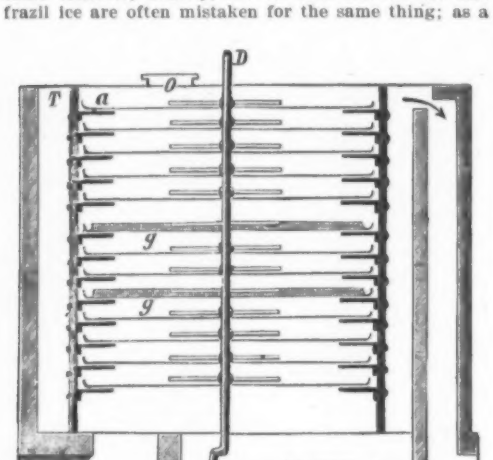


FIG. 1.—RIEBECK'S PLATE DRYING OVEN.

THE MANUFACTURE OF BRIQUETTES.

IN mining bituminous coal, as well as anthracite, considerable quantities of fine coal and dust are produced, the direct utilization of which is very difficult. The endeavor to utilize this waste coal has led to the development of an industry which has now become very extensive, the manufacture of compressed coal or briquettes.

The process of manufacture consists essentially in compressing the fine coal in molds, and thus converting it into larger pieces of regular form and sufficient hardness and density for economical transportation and use.

Before it is pressed, or briquetted, the fine coal must be prepared and pulverized. The quality of the raw material may be favorably affected by proper preparation, and the fuel is further improved in the pressing, so that the manufacture of briquettes, although its importance entitles it to the rank of an independent industry, may also, like the manufacture of coke, be regarded as a method of improving the quality of coal.

The immense importance of the industry, and the economical advantage of converting almost worthless refuse into excellent fuel, are, of course, obvious. There is one fundamental difference between the manufacture of bituminous and that of anthracite briquettes. Anthracite dust cannot be formed into briquettes without the admixture of some adhesive substance, while soft-coal dust needs no such addition. We will now examine the essential features common to both processes.

Attempts were made, long ago, to utilize the fine coal of bituminous mines by pulverizing it, if necessary, and mixing the powder with water to a stiff paste, which was then formed by spreading or packing in molds or by kneading with the hands. The lumps thus formed were simply exposed to the air until they became dry enough to burn.

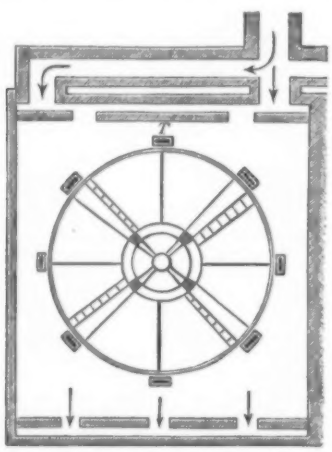


FIG. 2.—RIEBECK'S PLATE DRYING OVEN.

This exceedingly primitive method led to the manufacture of the so-called wet briquettes by a process similiar to the above, except that machinery was employed.

The coal was crushed between rollers, mixed with water by a mechanical contrivance, and pressed by a machine quite similar to those used for peat.

The paste, driven forward by endless screws, exuded from an orifice (usually heated by steam) in the form of a continuous strip. This was then cut into pieces of equal length, which were laid upon platforms to dry.

The imperfections of such a process are obvious. Its most serious defects are that more water is added to the already wet coal, that the briquettes dry so imperfectly as to retain from 30 to 35 per cent of water, and that, like peat briquettes, they are compressed only very slightly. Though the soft masses contract and stiffen somewhat in drying, they never attain the degree of hardness needed to make them suitable for transportation to great distances. The result is very different when bituminous-coal dust is compressed and formed into briquettes, not only without the addition of water, but after preliminary desiccation. By this method, using pressures of many hundred atmospheres, hard, transportable, weather-resisting briquettes are produced, which contain very little moisture and do not crack in the fire. In this process no adhesive need be added as the bitumen of the coal suffices.

The suitability of a coal for briquetting depends, therefore, upon its richness in bitumen, that is to say, upon its chemical constitution. As a general rule, inferior bituminous coal is more suitable for briquetting than the better grades. The best Bohemian soft coal, for example, yields good briquettes only when freshly mined.

This is probably due to oxidation of the bitumen by exposure to the air The percentage of mineral admixture is also of importance. Sandy coal forms poor and fragile briquettes, besides wearing out the press rapidly. Very soft "young" coal and lignite, which possess a fibrous structure, are not suitable for briquettes.

The manufacture of bituminous briquettes comprises four operations—sorting, crushing, drying, and pressing or briquetting. As the coal comes from the mine, it is sorted, by various devices that cannot be described here, into sizes down to the smallest that can be burned without preparation, and into still smaller fragments and dust, which together form the raw material of briquettes. That portion which is sufficiently fine goes at once to the drying ovens, whither the remainder follows after it has been crushed, either between cast-iron rollers or in the newer machines, which are identical in principle with ordinary coal breakers.

The drying of the coal is not only the most important, but also the most difficult operation in briquette making. For the adaptability of the material to briquetting depends largely upon the manner and degree of desiccation, and as the requisite degree of dryness is not the same for every variety of coal, no universal rule can be laid down. In the case of a coal of unknown composition, the drying process must be guided by the results of experiment.

The proportion of water in coal fresh from the mine ranges from 40 to 60 per cent, and as this must be reduced to 20 or even, in some cases, 10 per cent, a great quantity of water must be removed. Besides, as the quantity of water varies with the nature of the coal, the same drying apparatus will not give satisfactory results in all cases. But this very fact, in connection with the endeavor to make the apparatus as efficient and economical as possible, has led to a very great improvement within recent years. We now possess in the tubular drying oven of F. A. Schulz, of Halle, an apparatus which practically meets every requirement. In addition to this, a few older systems will be described, because they are still used in many works which cannot be classed as superannuated. The drying apparatus is heated, according to its construction, by combustion gases, steam, hot air, or steam and hot air in combination.

Riebeck's plate drying oven is still in use in many places. It consists of from 14 to 17 ring-shaped cast-iron plates, *a* (Figs. 1 and 2) supported by twelve surrounding columns, *T*. The total area of the plates is from 140 to 170 square meters. The coal, strewn upon the plates, is moved spirally by stirrers, and falls from plate to plate through holes at their edges. The stirrer-arms, *g*, are attached to a vertical shaft, *D*, and carry movable blades which are so adjusted that the coal moves alternately outward and inward, being kept on the plates by outer and inner rims 10 centimeters high. The dry coal falls from the lowest plate into a short worm, which delivers it to a long collecting worm that runs beside the row of ovens.

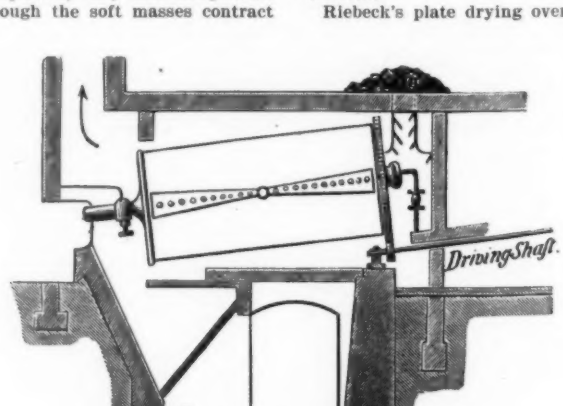


FIG. 3.—SCHULZ'S TUBULAR DRYING OVEN.

The plates are surrounded by brick walls, and the gases from a furnace below are conducted through a pipe to the top of the oven, whence they pass down with the coal to the bottom, where they escape, laden with water vapor, into the chimney. Hot air is used in Rewold's ventilating oven, and both steam and hot air in Jakobi's tubular kiln. In both the coal glides by its own weight over a series of overlapping sheets of iron resembling Venetian blinds. A pair of such constructions is inclosed by cast-iron plates, and the hot air streams up through their interstices, and dries the coal as it falls. The steam plate oven made by the Zeitzer iron works resembles the plate oven already described. The coal is moved by stirrers over plates, but these have hollow bottoms, through which steam circulates and heats the coal.

All plate ovens have the common disadvantage of needing stirring apparatus, which often breaks down. This inconvenience is avoided in the happiest manner in Schulz's tubular oven, made by the Buckau machine shops.

The Schulz oven (Fig. 3) consists of an inclined cylinder 6 to 6.4 meters (about 20 feet) long and 2.2 meters (7 feet) in diameter, containing more than 200 wrought-iron tubes, 95 millimeters (4 inches) in diameter. The cylinder rotates about a hollow axis, which serves also to admit steam to the space between the tubes. The coal is fed into the tubes from a hopper, and glides along them. By varying the speed of rotation of the cylinder, the amount of drying action may be regulated in accordance with the dampness of the coal.

FIG. 4.—BITUMINOUS BRIQUETTE FACTORY.

This drying apparatus, the details of which must be omitted, now ranks as the best and most complete. It possesses the special advantage that it can be installed directly over the press.

Pressing or briquetting is done by various improved forms of the Exter press, which was devised originally

for the making of peat briquettes. The press made by Sachenberg Brothers, of Rosslau, is thus described by Boernstein: A plunger of the size and shape of the largest face of a briquette receives a horizontal impulse from a shaft driven by a horizontal engine. A heavy flywheel takes up the whole work of the engine, and transmits it to the plunger during the brief impact. The mold consists of four parts, top, bottom, and sides, and is about one meter in length. The proper quantity of dried coal dust is dropped into the mold in front of the plunger when the latter is drawn back, and is then driven forward by the advancing plunger into the mold, which tapers slightly. Thereby the coal is subjected to a pressure that melts the bitumen contained in it and welds the mass solidly together. The mold holds about twenty briquettes, and the friction between the coal and the cast-iron or cast-steel sides of the mold sustains alone, without the introduction of any resistance directly opposed to the plunger, a pressure of from 1,200 to 1,500 atmospheres. The face of the plunger bears a depressed design. This is impressed, in relief, upon the back of the first briquette, which transmits it, as a depression, to the front of the next briquette, the back of which, at the same time, receives the design in relief from the plunger, and so on, so that the briquettes are locked together by these elevations and depressions on alternate faces, and may be lifted and carried by fifteens or twenties without the exertion of very great pressure upon the ends of the row.

To prevent overheating, decomposition of the bitumen, and generation of gases which, imprisoned within the briquettes, would cause them to crack on cooling, the molds are cooled by water pipes suitably arranged. After they are released from the press, the briquettes expand by one-thirtieth of their length, with further loss of water. On leaving the press they are so hot as to be in danger of taking fire if piled up without cooling, and therefore they are usually pushed forward in a single row by the press itself, through a long gutter, which ends in the storage yard.

One of the most disagreeable features of briquette making is the great quantity of escaping coal dust, which when mixed with air may easily give rise to conflagrations and explosions.

Fig. 4 shows the arrangement of a bituminous briquette factory. The coal is brought by an elevator and a crane to the crushing rollers, whence it goes to an oscillating sieve. The larger pieces go to a rotary mill, and the pulverized mass is again sifted and carried on an endless apron to a room directly over the Schulz tubular oven. From the oven it is conveyed mechanically to the hopper of the press. All the briquette factories equipped by the Buckau works are provided with Schulz ovens, which far surpass all others, and have without exception proven perfectly satisfactory. The ovens which were first erected, and have been in use sixteen years, have not yet needed any repairs, and do not even show any wear in the tubes. This proves that the coal rolls gently through the tubes almost without friction.

Schulz's oven has been greatly improved from time to time, and the recent introduction of a screw-thread (patented) inside the tubes has further increased its output by 20 per cent, so that no other drying apparatus of equal cost is at all comparable with it in capacity. Its other advantages, economy in steam, entire freedom from dust, and minimum danger of fire and explosion—are generally recognized. The dried coal is pressed at once, or after cooling, according to its character.

Briquetting engines are of the slide-valve, piston slide-valve, and Rider expansion type. The press frames are of various thicknesses, with or without tie-bolts.

The type of engine used depends upon the nature of the business and the steam pressure available, while the strength of the press frames is determined by the sort of coal used and the required output.

The very fine dust, which is carried off from the drying coal by the current of air and rising water vapor, is, for the most part, deposited in the numerous bends of the flues, whence it is collected and added to the general output of the oven. The remainder is precipitated by a water spray, so that the current which leaves the chimney is almost absolutely free from dust.

The firm has recently patented a filtering device, which reclaims the dust from the washings and leaves it with only 50 per cent of water, in which condition it may be added to the general fuel supply, experiment having proved that the addition of 15 or 20 per cent of the wet dust has no appreciable effect on the furnace fires. The filtered water is as clear as crystal, and again available for the same or other uses.

Thus the disposal of the washings, an important problem in all briquette factories, is effected by the double filter in the best and most advantageous manner.

In view of the constant operation of the factory, day and night, and the great and uncertain fluctuations in the power needed, due to variations in quality and moisture of the coal, a liberally designed and carefully constructed plant will be found cheaper in the end, despite its somewhat higher first cost.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Der Stein der Weisen.

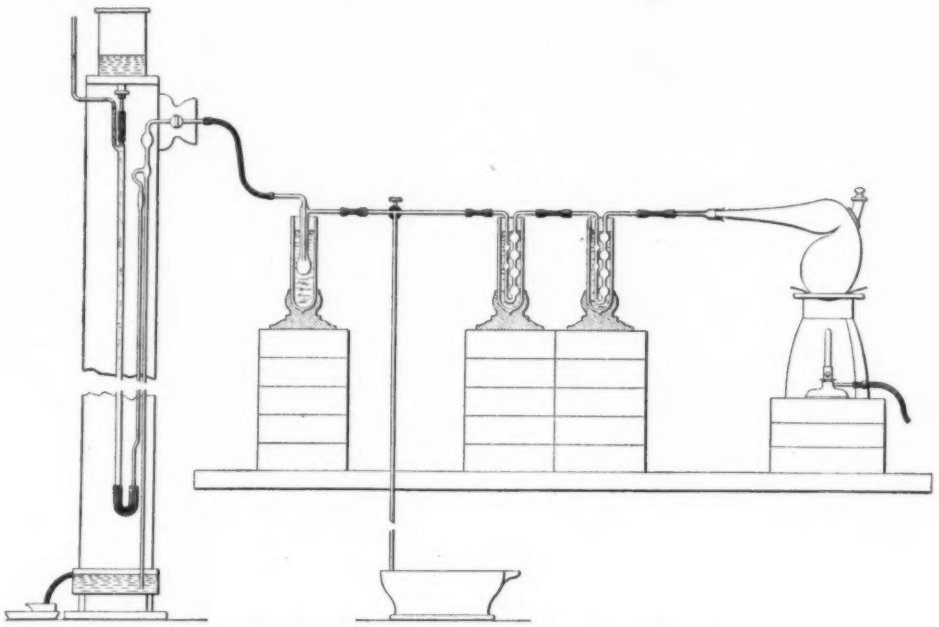


FIG. 2.—PREPARATION OF PURE IODOHYDRIC GAS.

Generator, drying tubes, three-way valve, discharge tube, condenser tube for solidified gas communicating with a mercury pump to remove the air and the uncondensed gases.

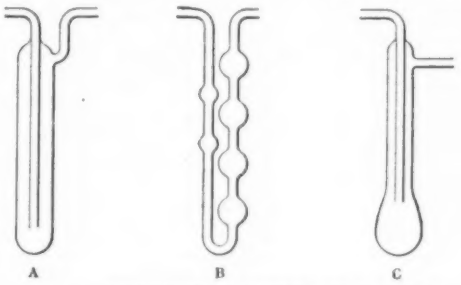


FIG. 1.—CONDENSER TUBES FOR THE PREPARATION OF PURE GASES.

THE PREPARATION OF PURE GASES.

THE chemistry of gases, or pneumatic chemistry, as it was called in the time of Lavoisier, is daily increasing in importance. Its usual methods are very difficult, for the preparation and control of gases demand attentive and constant care.

While it is comparatively easy to purify solids by crystallization and liquids by distillation, gases are, by their very nature, infinitely more difficult to obtain in a state of purity. This difficulty, however, is entirely dependent upon temperature, for if the latter is sufficiently lowered, the gases are first liquefied, and then solidified, so that we are brought back to the case of liquid or solid bodies. Hence M. Moissan has been led to invent, with the aid of the low temperatures now so easily produced by the use of commercial liquid air and carbonic acid, a general method for the preparation of pure gases, and to construct a very simple apparatus with which he has succeeded in obtaining many gases in a pure state, and in determining and verifying their physical and chemical constants.

An example will show how difficult it is to obtain an absolutely pure gas by the ordinary methods. It is well known that pure carbonic acid is completely absorbed by potash. If this test is applied to carbonic acid gas prepared in the usual way, a residue is always left unabsorbed, unless very special precautions have been taken.

In fact, it could not well be otherwise, although no other gases are evolved, for the apparatus is originally filled with air which must be washed or swept out by the first portion of the carbonic acid gas generated if the remainder is to be collected in a state of purity. As the air clings obstinately to the walls of the apparatus a large quantity of carbonic acid is wasted in this way. With rare and costly gases, it is evident that this necessary "washing" of the apparatus becomes a serious inconvenience.

Again, the gas, evolved in most cases from an aqueous solution, must be free from water vapor. For this purpose it is passed through tubes containing calcium chloride, pumice stone saturated with sulphuric or phosphoric acid, or other driers. These drying tubes increase the air capacity of the apparatus and their corks, chemically attacked by the driers, may introduce other impurities.

In addition to air and water vapor, it is necessary to guard against other gases evolved by substances employed in the production of the gas desired, or arising from secondary reactions. For these, too, special absorbents must be employed, and the apparatus complicated with additional tubes.

The method adopted by M. Moissan does away with all these driers and absorbents. It consists in solidifying the gas after it has been dried and purified by passing through small tubes, cooled to progressively decreasing temperatures, in which the moisture and some of the gaseous impurities are deposited in the solid state. At the same time, the apparatus is exhausted by a mercury air pump, which operation removes the other gaseous impurities and the air, including air which may have been dissolved in the liquefied or solidified gas. At the end of the process the temperature is allowed to rise and the solidified gas first melts, then vaporizes, and is finally collected over a mercury bath. The constancy of the temperature of evaporation forms an infallible criterion of the purity of the product.

That air may be dissolved in liquefied or solidified gases is shown in a curious manner by solid chlorine which, when placed in a vacuum, bubbles, as silver which has absorbed oxygen does on solidifying.

The method of fractional solidification is capable even of effecting a systematic separation of the ingredients of a complex gaseous mixture.

Apparatus.—The gas generator (for example, the apparatus for the production of hydriodic acid from iodine, phosphorus, and water) is connected in series with a cylindrical glass vessel, *A* (Fig. 1) and two U tubes of the form represented in *B*, with bulbs alternating with capillary portions. The joints are cement-

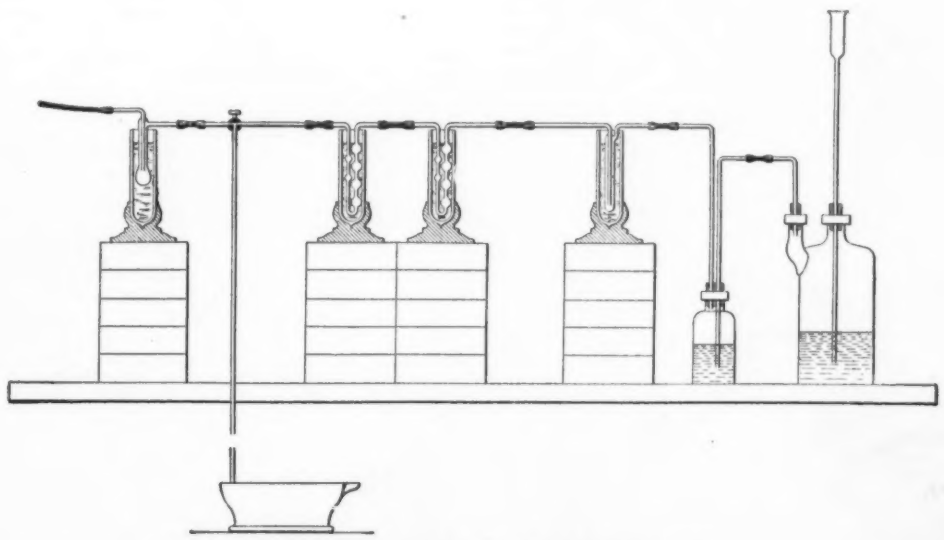


FIG. 3.—PREPARATION OF PURE NITROGEN.

Generator, washer, purifying and drying tubes, three-way valve, and condenser tube.

ed with shellac and the rate of flow is one liter in ten minutes. All three tubes are inclosed in double-walled Dewar flasks containing a mixture of acetone and carbonic acid snow, which produces a temperature of —32 deg. C. Nearly all of the moisture is precipitated as ice in the first or straight tube and the remaining traces are normally deposited on the extensive surface of the first U tube, where the gas is well churned together by the alternate contraction and enlargement of the stream. Experiment has shown that cooling to —30 deg. C. dries a gas so completely that it will not fume with fluoride of boron. The last tube, which is added merely as a check on the others, communicates by a three-way cock with the condenser, *C*, and with a tube which descends more than 76 centimeters, and dips into a mercury bath. The condenser, which is cooled to —80 deg. C. in the preparation of hydriodic acid, is connected with the mercury air pump by a lead tube.

The method of operation is as follows: First, the three-way cock is turned to connect the pump with the long efflux tube, and a vacuum is produced in the latter. Then, by turning the cock, the efflux tube is shut off and the pump connected with the rest of the apparatus. The generation of gas is begun and as the pump is worked a mixture of hydriodic acid, air, and water vapor flows through the apparatus. The water vapor is condensed in the tubes above described, the air is drawn off by the pump, and the hydriodic acid, the melting point of which is —55 deg. C., solidifies in colorless crystals in the condenser cooled to —80 deg. C. When a sufficient quantity has accumulated, the condenser is put into communication with the efflux tube and is no longer cooled. The hydriodic acid melts, evaporates and passes down the tube to a collecting vessel placed over the end of the tube in the mercury bath.

Another example of the application of the method is the production of nitric oxide by the action of nitric acid on copper. The reaction is very complex, and nitrogen and nitrous oxide are evolved also, but to eliminate them it is only necessary to keep the various tubes at suitable temperatures. The moisture is collected in a tube at —60 deg. C., the nitrous oxide in one at —100 deg. C., a temperature obtained by means of petroleum naphtha cooled in a bath of liquid air. The nitrogen is removed by the pump and the nitric oxide solidifies in a condenser cooled by liquid air to —167 deg. C.

Moissan's method has been employed in the preparation of carbonic and hydrochloric acids, sulphureted, arsenieted, phosphureted, and carbureted hydrogen, and hydrogen silicide. By it have been produced, also, the trifluoride of phosphorus, melting at —160 deg. C., and boiling at —95 deg. C.; the pentafluoride, melting at —83 deg. C., and boiling at —75 deg. C.; and the oxyfluoride, melting at —68 deg. C., and boiling at —40 deg. C.; as well as the trifluoride of boron which melts at —127 deg. C., and boils at —101 deg. C., and the fluoride of silicon, which solidifies at —97 deg. C., and vaporizes without melting at the atmospheric pressure.

By the same method Moissan and Binet du Tassoneix have prepared pure chlorine for the purpose of determining its density with the greatest possible precision. The result, 2.49, confirms the value of the atomic weight found by Scheele. Quite recently, Moissan and Chavanne have produced pure methane by the action of water upon aluminium carbide. This gas solidifies to a vitreous mass, melts at —180 deg. C., and boils at —164 deg. C. Its density is 0.555.

It is evident, then, that this purely physical method of purifying gases offers advantages over the chemical methods employed hitherto. It has been made possible by the facility with which low temperatures can now be produced and controlled.—From a French article in La Science au XX. Siècle by A. Bijant, assistant to M. Moissan at the Sorbonne.

THE RADIATION PRESSURE OF LIGHT.

PROF. ERNEST FORD NICHOLS, of Columbia University, recently lectured at the Royal Institution. In conjunction with Prof. G. F. Hull, Prof. Nichols has given us the most useful verification of the theory on this fascinating subject, which the most modern views on electrons render more and more complicated. At the beginning of the seventeenth century, the lecturer commenced, Kepler suggested that the tails of comets were turned away from the sun because the light from the sun pressed upon them. In view of the corpuscular theory of light, Newton thought the idea plausible, but he rather likened the appearance of the tails to the rising of smoke from the earth. Since then, the pressure of light has exercised many scientists and been held responsible for strange things. It was noticed in the eighteenth century that charcoal was driven back from the focus of a lens, which was concentrating the sun's rays. The Danube was supposed to flow more rapidly in the afternoon than in the morning, because the sun pressure from the west to the east helped the eastward current in the afternoon; and the night tides in the Meuse were assumed to be one-half foot higher than the day tides. De Mairan and du Fay made elaborate experiments. Fresnel found, in 1825, that no such effect could be traced to electrical forces; his failure was perhaps fortunate, Prof. Nichols thought, for in those days the corpuscularists would have claimed any result for their theory. Euler's mathematical deduction, of 1746, that a longitudinal wave-motion would produce a pressure in the direction of its propagation had been forgotten, when Maxwell showed, in 1873, that there is a pressure in the direction normal to the waves and numerically equal to the energy in unit of volume: $p = E/V$, where E is the energy in the unit length beams of light in ergs per second, and V the velocity of light. The formula holds for light falling normally on a body completely absorbing all the energy; when some light is reflected, the formula becomes: $p = E(1 + \rho) V$, where ρ is the coefficient of reflection. Now as the reflection coefficient may vary between 0 and 1, the radiation pressure should be twice as large for complete reflection as for complete absorption.

From thermodynamical considerations Bartoli arrived at the same formula. But all experiments still failed; and why they failed, Crookes's discovery in 1873 of the radiometer had made clear. At first Crookes thought that he had demonstrated the light pressure; but F. Zöllner showed by his ingenious experiments that the radiometer effect was about 100,000 times too large; and Crookes himself had soon recognized that the residual gas pressure was the great obstacle. In 1901, then, the lecturer continued, details of experimental verification came almost simultaneously from two quarters far apart: from Lebedew, in Moscow, and Nichols and Hull, in Dartmouth College, Hanover, New Hampshire. Lebedew* had followed Maxwell's suggestion to push exhaustion to the utmost. The American experimenters, it will be seen, proceed on different lines. Their apparatus was on the lecture-table, and the experimental demonstration was astoundingly simple and successful.

The apparatus is a torsion balance, vertically suspended by quartz fiber in a bell-jar, of glass, about a foot high. Two little glass disks, microscopic cover glasses, 13 millimeters in diameter, 0.17 millimeter in thickness, are hooked on the ends of a horizontal glass rod, fixed to a vertical rod held by the quartz. The hooks pass through holes in the disks, which are kept vertical with the aid of two other cross arms of glass. There is a mirror underneath the disks or vanes to mark the deflection, and the light of an arc lamp (alternating currents) is directed on the left- or right-hand vane through lenses and diaphragms. The disks are silvered on one face, and suspended so that, as a rule, one vane has its silver face in front, the other at the back. In order to eliminate the gas action, the reflection should be as perfect as possible; and in this connection it was noticed that the direct reflection from the silver was found higher than from the glass backed with silver, though the absorption of the glass was small, because the light had already passed through five lenses and plates of glass. Secondly, the vane system was occasionally turned through 180 deg., so that the light would fall in the first series, say, on the silver face of the left vane, and in the second series on the silver face of the right vane. Third, the gas pressure on the bell-jar was varied. The residual gas effect, Prof. Nichols remarked, is exceedingly complicated, and the problem not yet completely unraveled. When the light is turned on, the vane system always recedes; the little torsion balance was successfully steadied to start the demonstration, by exposing it to a few short light impulses. Supposing the light pushes the system back so that the mirror image on the screen travels to the left; it will return after a while and oscillate about a new zero. But now, after a little while, the gas effect, heating, convection currents, etc., will come in. The vanes will slowly begin to shift—it may be to the left, as before, or to the right—reversing the original effect; and if the light is now cut off, this creeping will continue for a time. The first experiment was shown in a gas of suitable density, which marked only the first sudden radiation push. Then more air was admitted into the jar, and after an interval the experiment repeated; the secondary slow gas effect now predominated. By studying the phenomena in atmospheres under various pressures, from 66 millimeters of mercury, down to 36, 20, 11, and 0.02 millimeter, Profs. Nichols and Hull observed that, with their balance, the repulsion effect changed into an attraction (suction effect) when the gas pressure was about 16 millimeters; attraction then continued down to 0.05 millimeter, but at 0.02 again repulsion was noticeable. Hence the ballistic determinations of the radiation pressure—in constants of the torsion balance—were made in an atmosphere of gas pressure 16 millimeters.

The gas effect depends mainly upon the silvered face, because the absorption in the cover glass vane will be small, for the reason stated above. This will be heated and convection currents set up, which will tend to move the system if the vanes are not absolutely vertical; this effect should be reversed by turning the whole system through 180 deg., the apparent result being attraction or suction instead of repulsion. But the leaving gas particles will, owing to the radiation push or backward thrust, travel faster than the arriving particles. Yet in spite of these various difficulties, the radiation pressure measurements were much more concordant (varying between 19.7 and 20.2 scale divisions—e. g., in one series) than the energy determinations which were conducted on more or less recognized lines. The bolometer determination first resorted to proved unsatisfactory. The light energy was then absorbed by a blackened plate of silver, also about one-half inch in diameter, but 3.6 millimeters in thickness, weighing 4.5 grammes. Two diametrical holes were bored through this plate, one-quarter of the thickness from either face, and two thermo-couples inserted in these holes. Lebedew's first values had been too large; the lecturer's first values were too small. His final values of 1903 agree remarkably well with the theory. In order to make sure that the observed radiation pressure depended only on the intensity of the beam, and not on the wave-length, a screen of red glass or a water cell (9 millimeters of water) was interposed in some series of experiments; smaller readings were, and should be, obtained in these cases. We reproduce the final observed results of the radiation pressure, *p*, adding the computed results in brackets:

Through air..... $p = 7.01 \pm 0.02$ (7.05) in 10^{-5} dynes.
Through red glass $p = 6.94 \pm 0.02$ (6.86)
Through water cell $p = 6.52 \pm 0.02$ (6.48)

The pressure values are probably correct within 0.4 per cent; the greatest uncertainty (of possibly 5 per cent) affecting the energy determination, attaches to the diffuse reflection from the black surface. This radiation pressure of nearly one ten-thousandth of a dyne, the lecturer continued, was not smaller than what Boys and others had measured in gravitation work, and might play an important part in cosmic physics. Referring to Poynting's experiments on the radiation pressure at oblique incidence, and to Poynting's interesting speculations,* Prof. Nichols explained that while radiation pressure and gravitation diminish both with the square of the distance, the mass of a body varies as the cube of its radius and the radiation pressure as its square; and the ratio, radiation pressure to gravitation, would hence be inversely as the radius, radiation and absorbing powers being assumed constant. In small bodies the radiation pressure might, according to Schwarzschild, become eighteen times as large as the gravitation pull; in very small bodies diffraction would alter this ratio. How this combined effect would separate small particles from coarser ones, the lecturer demonstrated by another experiment. The diagram which he first threw on the screen provoked an outburst of enthusiasm, which Professor Nichols hastened to check by remarking that they were far from realizing the ideal conditions represented in the diagram. He had taken the very fine spores of a puff-ball, roasted and calcined them, and mixed the very fine carbon particles about 2 μ in diameter, of a density 0.16, with emery sand. This mixture was put in an exhausted glass tube, of the hour-glass type, such that the particles would fall through a stricture from the upper into the lower cylinder. The beam of light being directed on the stream a little below the stricture, a few specks of carbon were seen to be deflected away on a curved path, while the sand fell down in a straight line. His original tube having been broken on the passage over from America, a new one had been made in the Cavendish Laboratory, at Cambridge, and the best vacuum obtainable still further improved with the aid of cocoa-nut charcoal and liquid air.† The effect was still far too large, and one could easily conceive why. The charcoal was a powerful absorbent for both gases and rays, and the gas would be expelled under the intense illumination, so that we watched a kind of rocket action. Yet we could understand, the lecturer explained, that the radiation pressure would separate coarse from fine particles, or particles of the same size but of different density; and the multiple comet-tails (Donati's comet had three tails) and the spreading of comet-tails might be accounted for in this way. Bredichin had made calculations for comet-tails. The question was, however, exceedingly complicated. We had no idea of what was going on in those tails, and gravitation, light intensity, and radiation pressure in them might be much greater than on earth. The variation pressure in front of a hot body in motion would be greater than the radiation pressure behind, and the motion hence retarded. Further, J. J. Thomson had pointed out that a charged body would send out electrons, which again would have a very small repelling effect of their own; and Arrhenius had dwelt upon the part played by negative electrons emitted from the sun. Arrhenius' electrons would serve as condensation nuclei, and, driven away from the sun by the radiation pressure, would batter the tails of comets. On the other hand, the radiation pressure seemed to reverse the nebular theory of the universe; for the radiation pressure would scatter small particles, and the nebula would be the final and not the initial stage.—Engineering.

* See Engineering, vol. lxxii., p. 874.

* See Engineering, vol. lxxviii., p. 364.

† Compare Sir J. Dewar's lecture, Engineering, vol. lxxviii., p. 462.

BOILER INCRUSTATION.

THE Chemical Engineer gives an account containing a number of compounds that have great efficacy in preventing boiler incrustation.

M. E. Asselin, of Paris, recommends the use of glycerine as a preventive. It increases the solubility of combinations of lime, and especially of the sulphate. It forms with these combinations soluble compounds. When the quantity of lime becomes so great that it can no longer be dissolved, nor from soluble combinations, it is deposited in a gelatinous substance, which never adheres to the surface of the iron plates. The gelatinous substances thus formed are not carried with the steam into the cylinder of the engine. M. Asselin advises the employment of 1 pound of glycerine for every 300 pounds or 400 pounds of coal burnt. To prevent boiler incrustation:

1. For a 5-horse-power boiler, fed with water, which contains calcic sulphate, take: Catechu, 2 pounds; dextrine, 1 pound; crystallized soda, 2 pounds; potash, ½ pound; cane sugar, ½ pound; alum, ½ pound; gum arabic, ½ pound.

2. For a boiler of the same size, fed with water which contains lime: Turmeric, 2 pounds; dextrine, 1 pound;

sodium bicarbonate, 2 pounds; potash, ½ pound; alum, ½ pound; molasses, ½ pound.

3. For a boiler of the same size, fed with water which contains iron: Gamboge, 2 pounds; soda, 2 pounds; dextrine, 1 pound; potash, ½ pound; sugar, ½ pound; alum, ½ pound; gum arabic, ½ pound.

4. For a boiler of the same size, fed with sea water: Catechu, 2 pounds; Glauber's salt, 2 pounds; dextrine, 2 pounds; alum, ½ pound; gum arabic, ½ pound.

When these preparations are used add 1 quart of water, and in ordinary cases charge the boiler every month; but if the incrustation is very bad, charge every two weeks.

CONTEMPORARY ELECTRICAL SCIENCE.*

RADIATION PRESSURE.—J. H. Poynting considers a wave-train as a stream of momentum traveling through space, the momentum being manifested in the reaction, the back pressure against the source, and in the forward pressure when the waves reach an opposing surface. In the case of refraction of ordinary light, there will be reflection as well as refraction. The reflection always produces a normal pressure, and the refraction a normal pull. But with unpolarized light, a calculation shows that the refraction pull, for glass, at any rate, is always greater than the reflection push, even at grazing incidence. The author describes an interesting experiment showing the refraction pull. Two glass prisms were suspended at the ends of a torsion arm hanging by a fiber. A beam of light from a Nernst lamp was thrown upon one of the prisms at an acute angle to the surface. It emerged normally at the opposite surface, fell normally on the other prism, and emerged from it at an acute angle, and parallel to its original direction. The arm then turned as if the beam were an elastic string. The author calculates the effect of the sun's radiation on a particle 1/1,000 inch thick. He shows that if it revolved round the sun it would take two days longer to do so than the earth at the same distance, owing to a component of the radiation pressure which tends to retard it. It would describe a spiral, and would approach the sun at an initial rate of 800 miles per annum.—J. H. Poynting, Philosophical Magazine, April, 1905.

TUNING OF THERMOELECTRIC RECEIVERS.—A. D. Cole has made some experiments for the purpose of testing whether the wave-length of a linear receiver as used in Poincaré's and Righi's arrangements is twice the length of the receiver itself. He used two different Righi exciters, the two central spheres of the usual form being replaced by thin cylinders with rounded ends. In one exciter the radiating cylinders were each 37 millimeters long, and 3.1 millimeters in diameter, in the other 25 millimeters long and of the same diameter. The receiver was made of the same form and diameter as the exciters, but its length was variable, and a thermo junction of fine iron and constantan wires replaced the spark gap. The variation in the length of the receiver was secured by sliding tubes of thin metal over its cylindrical ends. The receiver was placed behind a cylindrical lens of a bottle containing half a gallon of benzine. Its efficiency in concentrating the radiation was such that the deflection was increased five times. The wave lengths were measured by three different interference methods. It was found that the interference curves showed the wave-length characteristic of the receiver and not necessarily of the exciter. The ratio of measured wave-length to receiver length is 2.52 and not 2.0 as assumed by Poincaré. When the receiver is tuned to a maximum the fundamental wave-lengths of receiver and exciter are the same.—A. D. Cole, Physical Review, April, 1905.

RADIATION FROM ORDINARY MATERIALS.—N. R. Campbell has experimented with vessels lined with various ordinary materials in order to discover the nature of the influence which the walls of a containing vessel are known to exert upon the spontaneous ionization of the inclosed air. He finds that this ionization, as already suspected, is due to some radiation proceeding from the wall, but that the nature of the rays, their charge and velocity, offer very serious difficulties in their investigations. He is, however, able to say that part of this radiation from certain materials, such as tin, zinc, graphite and platinum, is analogous to the secondary radiation excited by Röntgen and other rays, being caused by the penetrating ionizing rays which Cooke has cut off with thick lead screens. The absorption coefficient of air for this radiation is comparable with that of air for the *a*-rays from radium. The fact that the absorption coefficient is different for different materials makes it unlikely that the radiation is due to radio-active impurities. It seems, in fact, to be an inherent property of the material. All elements are most likely radio-active to some degree. It might be expected that some of them would give off an emanation, but all efforts to detect such an emanation from lead, zinc and aluminium have hitherto failed.—N. R. Campbell, Philosophical Magazine, April, 1905.

RESONANCE IN WIRELESS TELEGRAPHY.—G. W. Pierce, continuing his researches on electromagnetically-connected wireless circuits, shows that the proper adjustment of the antennæ is of vital importance. The proper adjustment is not attained by making the mast circuits at the two stations equal. Even with the mast circuits at the two stations constituted of coils and antennæ of exactly the same dimensions, it is possible, under conditions that are not unlikely to occur, to obtain the singular result that the amount of energy in the side circuit at the receiving station is insignificantly small, while at the same time the capacity of the condenser in this circuit must be made infinite to obtain resonance. The author's experiments also show that the resonance conditions are multiple-valued, so that unless the circuits are well understood there is danger of setting the receiving circuit to resonance with some feeble oscillation and thus failing to take advantage of a more energetic train of waves. The fact, however, that the conditions for resonance are multiple-valued does not preclude the possibility of simultaneously operating a large number of wireless telegraph stations without interference, because under proper conditions the resonance is sharp and the number of possible variations of the circuits is large.—G. W. Pierce, Physical Review, April, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

ELECTRICAL NOTES.

A problem which is only now commencing to pass outside the domain of the physicist into that of the engineer is that of the etheric transmission of power. The development of electric wave telegraphy is an excellent instance of the various stages of the solving of an electrical problem. In this case, Maxwell and Hertz settled the first stage and formulated the laws of the transmission of etheric waves. Branly supplied an important element when he invented the coherer. Marconi's enthusiasm, skill, and perseverance, aided by Fleming and other numerous competent co-workers, has carried the third stage to its present development. We may consider that the etheric transmission of signals up to a given distance, and notably for the purposes of signaling to and between ships at sea, is practically solved, although there are many secondary problems arising out of it. No doubt the first and most important of these is the production of wave trains sufficiently powerful and of the right character to yield the best results. Fleming has particularly devoted himself to this subject, and the value of his inventions has been fully acknowledged by Marconi.

Telegraph companies have been moving in a rather leisurely way so far as printing telegraphy is concerned. Nor are these the only difficulties the printing telegraph inventor has to face. Assuming that his printing telegraph system works well and gives satisfaction from a mechanical point of view (a very big assumption) and shows some saving of labor, even under the foregoing conditions, he has still to fit his unfortunate system, not merely into one bed of Procrustes, but in half a dozen of them, every one differing in length. There are two classes of commercial telegrams, known in England as S and X messages. The former go direct from one town to another, say from Liverpool to London, and are delivered there. The other class of messages go, let us say, from Liverpool through London to Paris. In London these X messages have to be written out as they are received from Liverpool, and then sent on to another circuit for transmission to Paris. These two classes of messages exist in all countries, and most telegraph administrations have two different telegraph forms to distinguish them. Also it is necessary for a telegraph administration to keep a copy of all messages delivered, that is to say, all S messages. But the X messages for further transmission do not require to be copied. In England, carbon copies are made of S messages. On the Continent a note is made of the preamble and the address. A printing telegraph cannot distinguish between S and X messages, and in any case making carbon copies of short twenty-word messages on a typewriter wastes so much time that it is out of the question. Also it is not possible to have two different telegraph forms, one for X and the other for S messages. That means that a special telegraph form has to be prepared for the page printing telegraph, and great telegraph administrations are very reluctant to change their telegraph forms for the convenience of a new and untried invention. It marked a distinct stage in the advance of the Murray system when the British and the German telegraph administrations decided to make up special telegraph forms for use with this apparatus. As for preserving copies of S messages, that difficulty was experienced in the United States when typewriters were first introduced into the telegraph service, and it was found that the only practical solution was to take wet press copies, the telegrams and the damp copying paper being passed through between a pair of power-driven rollers. The use of typewriters in telegraph offices is now practically universal in the United States, and the press copying of telegrams meets all requirements. For some reason that is not quite clear, European telegraph administrations seem reluctant to adopt this plan, and up to the present the preambles and the address of S messages have been noted by hand at the rate of about fifteen words a minute, an anti-climax when it is remembered that the messages are typewritten by the Murray printer at the rate of 120 words a minute. Press copying, however, will no doubt be adopted as soon as the page-printing telegraphs come into more general use in Europe. Another trouble is that for the sake of security figures have to be repeated. This is not always done with the Hughes, but with new telegraph systems until they have been proved to be reliable it is a necessity, and the repetition of figures in short twenty-word messages obviously reduces the speed and the possible labor saving. A small but unexpected difficulty was encountered in England owing to the shilling stroke and fraction bar in a typewriter being identical. For instance 7/8 may be read seven-eighths or seven shillings and eightpence. In one or two instances merchants have suffered loss through this ambiguity. It is not difficult to provide a printing telegraph with the fractions up to and including eighths, thus ⅞, but the ambiguity is confined to England, and for international traffic the International Telegraph Convention has specified a list of characters which does not include these fractions.

SCIENCE NOTES.

For ascertaining the depth of the sea without the use of the sounding lead or other devices, the Norwegian engineer Berggraf has invented a unique method. He sends sound waves perpendicularly into the water, and measures the time they require to return to the surface after having been reflected from the bottom of the sea. The speed of the sound in water being known, the length of the space passed through is immediately determined; one-half of it is the depth of the water. A period of four seconds, for instance, between the departure and return of the sound corresponds to a depth of 2,400 meters. The device consists, according to the Vossische Zeitung, of a transmitter, a receiver, and a time-piece. The electro-magnetic transmitter sends to the bottom of the sea a series of deep sounds, which upon their return are taken up by the microphone. A listening device or receiver cut in in the same circuit reproduces the sounds. Naturally, the sound is exceedingly weak upon its return, so that it is hardly perceptible, but it is rendered distinctly audible by the vibration of the receiver or ear-piece being reinforced by a sounding tube.

An invention which is of great value to those compelled to wear spectacles has been devised by a French scientist. The device is described as the isometrope lens, and it offers many advantages over the optical glass now in use. It is immune from the greenish tint which the ordinary optical glass shows; and one can see more clearly through it. The isometrope glass can also be made much thinner than the optical glass, with the result that the focus is more spread—a considerable advantage to the eye. Further, by its utility the injurious violet rays are entirely cut off from the eyes. For instance, when specimens of the two kinds of glass are placed behind the screen of a Roentgen ray apparatus, the isometrope lens shows quite black behind the screen, thereby demonstrating that the violet rays have been stopped in transit. The ordinary glass, however, appears quite transparent, testifying to the passage of the violet rays. This advantage renders the isometrope glass of great value to those who suffer from defective eyesight, since by its use great relief, ease, and rest to the eyes are possible. The isometrope is made from a combination of several substances by a secret process.

The Terrestrial Heat Produced by Radium.—Dr. Liebenow, in the Physikalische Zeitung, of Berlin, seeks to estimate the quantity of radium which might produce the interior heat of the globe, if, as certain investigators suggest, radium is distributed throughout our planet. But the average theoretical conductibility of the earth is not fixed, nor the scale of increase in the temperature according to the depth. Assuming the most recent figure, that of Heumann and Hecht, for the conductibility and an increment of one degree centigrade for thirty meters of penetration, Dr. Liebenow finds a terrestrial emission of 10^{13} gramme-calories per second. On the other hand, if, according to Paschen's corrected value, a gramme of radium develops 226 gramme-calories per hour, it follows that 16 grammes of radium would furnish 1 gramme-calorie per second, and that 2.10^{14} grammes of radium would be necessary to represent the heat of our globe. If we suppose this quantity distributed equally through the mass of the planet, we would find only 1-5,000 of a milligramme per cubic meter. Considering the concentration of radium in the terrestrial crust, it must be assumed that the rate of increase of temperature noticed in the sinking of wells does not extend to great depths.

As early as one hundred years ago a distinct movement for the betterment of agriculture had set in. This movement was largely educational. It was an effort to improve the farmer, quite as much as to improve the farm. Washington was vitally interested in the problem. He wished to have a central board or clearing-house for agricultural information. The full fruition of his hopes came with the establishment of a secretaryship of agriculture in the President's cabinet, in Benjamin Harrison's administration. In 1799 a concrete proposition for the establishment of an agricultural college in Pennsylvania came to an untimely end. In 1821 instruction was given in agriculture in the lyceum at Gardiner, Maine. In 1824 a school of agriculture was opened at Derby, Connecticut. A number of other similar attempts were made previous to the passage of the Land Grant Act of 1862, but of these only the Michigan Agricultural College persists. The gist of the whole movement was to adapt education to men's lives. The culmination was the Land Grant Act, the purpose of which is "to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." So far as agriculture was concerned, the Land Grant Act was somewhat premature. The developing and organizing mechanical and engineering trades were the first to profit by it. Agriculture will now have its turn.

We are now just coming to the large question of adaptation of special areas to special purposes. In the future one of the problems will be the more perfect adaptation of the kind of farm to soil and climate. As an illustration, the production of domestic animals for meat and for wool has been most extensive on the western border of the developing country for economic reasons, and not because the area is naturally best adapted to this enterprise. The Mississippi valley is

primarily adapted to the production of cereals and not nearly as well adapted as the North Atlantic States to the production of grass either as pasture or hay. These Atlantic States are particularly adapted to growing all kinds of trees and of grass. In the course of time, therefore, we may expect that the production of live stock will become more important in the East. Out of this grow some immediate problems. At present, live-stock husbandry in the East can be carried on economically only when large tracts of land can be purchased at low price. It is possible to purchase small tracts of land at comparatively low price, but not possible to purchase large areas. More of the live stock will be raised upon small farms within the more densely populated districts, with comparatively few animals to a place. This will lead to the question of maintaining the improvement in domestic animals. It will mean the gradual substitution of soiling systems for pasturing systems, and this will lead to remoter economic and social changes.

ENGINEERING NOTES.

It is useful and necessary to recognize a distinction between efficiency of a boiler and boiler efficiency, the former a constant for any particular boiler, and the latter produced by other influences which may be variable in character and effect, which, acting in conjunction with the efficiency of the boiler produces various results, and affecting the efficiency produced through the boiler.

Work on the Kiel Canal.—In the Zeitschrift fuer Architektur Herr Lüdecke gives a detailed account of the excavations at Grünenthal, on the line of the canal running from the basin of the Elbe to that of the Eider. It has a length of 4,650 meters and has caused the removal of ten millions of cubic meters of earth. This is deposited at the extremities for the purpose of enlarging the railway embankments.

Recent Coal Resources of Belgium.—Deep borings have lately been made for ascertaining the coal deposits supposed to exist in the valley of the Campine. A zone 80 kilometers in length by 20 in breadth, extending from the Meuse to the confines of Antwerp, has been traced. According to calculations made by M. Lenvel, these deposits, up to a level of 1,500 meters, would represent a total of eight thousand millions of tons of combustible material. The province of Limburg is especially favored.

Can a thoroughly practical concrete fence post reinforced with steel be made sufficiently cheap to be used by farmers? The advantages of such fence posts would be many. The price of wood, particularly of the varieties used for fence posts, is continually rising, and even now the price is almost prohibitory in some sections of the country. Further, a properly constructed concrete fence post would be permanent, as it would neither rot nor undergo disintegration. A variety of methods of reinforcements have already been tried, and the experiments are being pushed as rapidly as possible. The results so far obtained have been most satisfactory.

High heat efficiency in steam generation requires, first, a good apparatus, and second, that it be properly manipulated. The faults of the fireman and furnace operator are well understood and recognized, and he is much to be blamed for poor results. But it is quite the popular thing, however, for the entire blame to be placed on the man who manipulates the fire, when in fact the apparatus is often very faulty, and in some cases very poor results are nearly all due to the apparatus, yet the man is blamed for the bad engineering of the maker and designer. And often an operating engineer or proprietor seeks in the fireman a degree of intelligence and knowledge of these complicated processes, much greater than he himself possesses.

Employment of Volatile Liquids in Explosion Motors.—For a long time the idea has been cherished of increasing the force of explosion motors by mixing with the gases water designed to be vaporized under the action of the high temperature developed in the cylinder. Thus the Lenoir motors, constructed by Marinoni, have an arrangement for spraying water in the jacket of the cylinder. Herr Schreber discusses in Dingler's Polytechnisches Journal the question of the increase of power to be expected from this operation, and shows by calculation that it cannot increase the pressure of the gaseous mixture, but that its action may be useful in counteracting the heat produced by the compression. He draws important conclusions from his reasoning for the construction of motors, especially two-cycle motors, working with combustible liquid, vaporized by the heat of compression, the action of the pump being directed to the injection of the air necessary for the explosion. The escape of the burned gases may thus be assured, without loss of combustible gas, as in many of the present two-cycle motors. He also studies the thermic working of an explosion motor, in which a liquid designed for cooling the cylinder is injected during the period of compression (alcohol, for example) and applies the formulas thus established to the system of spraying previously referred to, and shows why such a motor can work only with gasoline, petroleum not being sufficiently volatile, and the small drops of petroleum and water commingling inopportunely. In fine, according to his reasoning, the injection of water should be as limited as possible, and made in such a way as to secure its immediate spraying, notwithstanding the pressure existing in the cylinder from the effect of the compression. Then the injection should occur only during a part of the compression.

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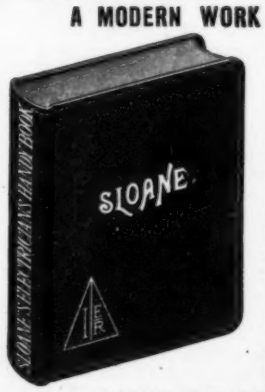

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